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Configuration of Small Scale Biomass Harvesting and Transport Systems

by

Kipping & Associates Ltd.

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by

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ABSTRACT

A study was performed to configure nominal 25, 50 and 100 green tonne/day whole-tree chip harvesting systems and to evaluate the economic feasibility of operating these systems as independent businesses on private woodlands in the maritime provinces. Representative small cable skidders, mobile wood chippers, feller-bunchers, grapple skidders and semi-trailer chip vans were evaluated for production capacity, utilisation, and unit cost of production when operating at the desired harvesting system capacities. Optimum systems were then designed for nominal production rates of 25, 50 and 100 tonne/day using this equipment. A discounted cash flow analysis was performed in each case to assess economic viability.

For current market price range for fuel chips ($14-$16/green tonne), the results indicate clearly that none of the determined small scale systems are economically viable as independent businesses.

At current prices for whole-tree chips for fiber ($25-$27/green tonne), two systems were determined to satisfy the economic viability criteria. The first, based on felling with chainsaw, cable skidding, and production at 120 tonne/day, is described in Table 4.5. This system was determined to be preferable to the second best alternative, a feller-buncher - grapple skidding type system (Table 4.7) which would also produce at 120 tonne/day. A nominal 50 tonne/day cable skidding based system configuration (Table 4.2) was also determined to be promising if operated in favourable circumstances.

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1 Introduction

There is a need for cost effective small scale biomass harvesting systems in the Maritime Provinces. A significant portion of forest land is held in small parcels of non-industrial private woodland. For example, in New Brunswick, 26,707 owners hold a total of 1.11 million hectares or 19% of the provinces' forest land in parcels ranging between 11 and 199 hectare in area[1]. These woodlands have been, and continue to be, an important source of supply to the regions forest industries. And in the future, private woodlots are expected to become more important to the continued stability of forest industry supply requirements given projected shortages from Crown and Industrial woodlands.

Although the condition of private woodlots varies greatly between individual properties, many are in poor condition and require increased forest management if their productive potential is to be realised. For example, it is estimated[2] that 1.13 million m^3 of softwoods are dead or dying on private woodlots in New Brunswick because of spruce budworm infestation. In addition, past cutting practices and natural succession have resulted in a presently substantial and under-utilised hardwood resource on these lands. Clearing of budworm damaged stands to enable regeneration, and increased hardwood utilisation and/or conversion of hardwood to softwood stands, represent both a large source of biomass for fuel or fibre, and needed forest management activity.

However, increased management of private woodlands is inhibited by a number of problems which have been fully described in a recent study[2]. One of these problems, which is the focus of this report, is the lack of harvesting systems that are both acceptable to the land owners, and yet cost effective and profitable for the harvesting system contractor. Typically, private woodlot owners cannot do their own harvesting and have to rely on independent contractors. These contractors are normally equipped with large

scale equipment suited to operations on crown and industrial woodlands. Owners experiences with these contractors have often been discouraging, frequently resulting in no further harvesting being done. A solution to this barrier to increased harvesting activity on private woodlands would be scaled down, yet cost effective, biomass harvesting systems suitable for operation by independent logging or silvicultural contractors.

This report describes a study which was performed to configure small scale biomass harvest and transportation systems designed to have nomimal capacities of 25, 50, and 100 green tonnes of wood chips per day.

The report was prepared by Kipping & Associates Ltd. for the Canadian Forestry Service, Maritime Forest Research Centre, under the terms of Canada Department of Supply & Services Contract No. OSC84-00337.

The study objective, as stated in the contract documents, was to develop small scale biomass harvesting system(s) which incorporate available equipment into a cost effective operation. It was specified that the study was to be comprised of the following work. (1) Identify the available, and potentially available harvesting equipment. (2) Design systems that will produce 25, 50 and 100 green tonnes per day of whole-tree chips. Evaluation of the most appropriate system components is to be done on paper and/or through simulation exercises. (3) All stages of the system operation are to be considered from standing tree to the mill gate. (4) In performing analyses of potential systems, consideration is to include (a) the capital cost of systems by component and total, (b) operating costs by component and total, (c) unit production costs ($/tonne), (d) unit transportation costs ($/tonne), (e) machine specifications and/or modifications with estimated costs, (e) equipment life, availability, mobility, and utilisation rate and (f) equipment limitations as determined by the size or other characteristics of the biomass. (5) Recommendations of the most appropriate system(s) are to be made based on the analyses results.

Section 2 following defines terms and their intended meaning in the context of the study, as well as stating the major assumptions upon which the analyses were based. Section 3 presents the results of component harvesting and transportation equipment selection and costing. The results of optimum configurations of systems as determined for each nominal capacity

range, together with estimates of economic performance, are presented in section 4. Section 5 presents the results of the discounted cash flow financial analysis of each system. The conclusions and recommendations are presented in section 6.

2 Definitions & Assumptions

Terminology

The following conventions of terminology and meaning apply throughout the report.

The unit of length is the meter (m.) and the unit of diameter measure is the centimeter (cm.).

The usual unit of weight is the metric tonne and means green tonnes of wood unless specifically described as ovendry tonnes or tonnes of specified moisture content. The kilogram (Kg.) is also used as a unit of weight when referring to the density of materials.

The unit of volume is the cubic meter (m^3) which means solid wood volume. Density refers to solid wood density in units of Kg/m^3. Bulk density is used in referring to wood chips, or other loosely packed biomass material, and is also expressed in units of Kg/m^3.

The unit of area is the hectare (ha). In referring to stand density, the unit used is tonnes/ha meaning green tonnes of biomass per hectare. Tree diameter means the diameter at breast height and is abbreviated DBH. Average stand diameter refers to the the average DBH in cm. of all trees prescribed for removal, or which are actually removed, by a harvesting operation. All stands are discussed in terms of their characteristics of average stand diameter (cm DBH) and stand density (tonnes/ha). For study purposes, the conversion of biomass volumes to weight was performed using the solid wood density and bulk density values described in the assumptions below.

Harvesting system capacity is referred to in terms of nominal tonnes/hour or tonnes/day. Nominal means the capacity at which it is intended they operate, or for which they have been designed and can be translated as meaning roughly or approximately. Production rate means the actual production of a machine or a system in tonnes per unit time. In referring to both capacity and production rate, tonnes per hour means tonnes per scheduled hour if unspecified as either tonnes per scheduled hour

(tonnes/sh) or tonnes per productive hour (tonnes/ph). A day as used in the study signifies a work day of eight scheduled hours.

The relationship between scheduled and productive hours is established by the value of utilisation for a specific machine or system. Utilisation (U) is defined as the ratio of productive time to scheduled time. Utilisation is expressed as a percentage (%) since it is dimensionless.

Assumptions

The study analyses and results are based on a number of assumptions relating to conditions and circumstances under which the various harvesting system configurations operate. The assumptions, in each case, are considered to be reasonably accurate representations of actual conditions or limitations that the small scale harvesting system operator would have to ensure or deal with before proceeding with setting up an operation.

1. Sites with less than the following minimum characteristics are not operated -; average stand diameter 15 cm. DBH. -; stand density of 100 tonne/ha. -; 10 hectare operable area.

2. The market price range for whole-tree chips for fuel is $14-$16/tonne and for whole-tree chips for fiber, $25-$27/tonne. Further, these market prices do not change significantly in real terms with time.

3. The harvesting system will operate within a maximum radius of 160 km. (100 miles) of the market location. Also sufficient resource is economically accessible within this area for sustained long-term harvesting system operation at its nominal capacity (either 25, 50 or 100 tonne/day) at an average of 200 productive days/year, or approximate annual productions of 5000, 10,000 and 20,000 tonnes/year respectively.

4. Stumpage costs are nil or negligible.

5. The system operating methods are either clearcutting, strip clearcutting, or mechanized thinning or trail cutting operations which can be performed effectively in the operated stands with either small cable skidders, or small feller-bunchers and grapple skidders.

6. At the harvesting sites, landing construction, and/or any necessary road construction or upgrading, is contracted. The harvesting system equipment such as skidders and feller-bunchers, is moved to new sites during road construction/improvement, using either the road contractors trailer equipment, or under separate contract. The cost of all necessary road and landing construction, and equipment moving is equivalent on average to $1.00/tonne.

7. The harvesting system operator works as a crew member/foreman, in addition to performing necessary management duties, thus providing some economy in operating costs.

8. The crew members are experienced and skilled at operating the system equipment and in performing routine machinery maintenance. Each crew member is responsible for machine maintainence and production. Good judgement is exercised in machine operation, so that required repairs and downtime due to breakdowns are minimized. The rate of pay for all crew members is $8.00 per scheduled hour, except for the truck tractor driver whose rate of pay is $10.00 per scheduled hour.

9. Dumping and scaling (weighing) equipment are available at the the point of delivery, thus precluding the need for the harvesting system operator to own self-unloading chips vans or onboard weighing equipment.

10. For the conversion of solid volume to weight, the following values are assumed. The average density of green wood is 800 Kg/m^3 for hardwoods, and 650 Kg/m^3 for softwoods. For mixtures of hardwoods and softwoods, the average density is equal to the weighted average of the preceding values corresponding to the proportions of each in the mixture.

11. The solid volume content of whole-tree chips is assumed to be 40% , as deposited in chip vans by the chipper. The corresponding average bulk density for chips are therefore 320 Kg/m^3 for hardwoods and 260 Kg/m^3 for softwoods. For mixtures of hardwoods and softwoods, the average bulk density is equal to the weighted average value corresponding to the proportions of each in the mixture.

3 Harvesting and Transportation Equipment Selection

Initally, a wide range of harvesting machines were considered as possible candidates for the harvesting system components. Possibilities were identified from manufacturers catalogs, forest industry literature and publications, and from the writers' experience with small scale harvesting systems operation. The New Brunswick forest products marketing board, several county marketing boards where harvesting systems were determined to be operating, several harvesting system operators, and a number of individuals with extensive knowledge of forestry equipment were also contacted to discuss equipment choices. An excellent publication[3] was obtained on the subject of large scale whole-tree chip harvesting systems which included a catalog of equipment. The catagories or individual machines types that were identified as initial possibilities included cable skidders, grapple skidders, mobile chippers in six different size classes including terrain chippers, forwarders, feller-forwarders, feller-bunchers, modified farm tractors, swath harvesters, and experimental slash harvesters such as the Recufor and the Swedish made Morgardshammar shredder.

A short list was produced from these candidates after preliminary analysis of costs and production capacity. For machines where cost and production capacity were within range for the subject systems, two further criteria were applied. (a) The equipment had to be specifically designed and manufactured for forestry operations, and (b) it had to have an identifiable history of successful forest industry use. These conservative criteria were intended to reflect the judgement prospective operators would most likely apply in selecting harvesting equipment. For the independent harvest system operator the financial risk is just too great to consider using unproven equipment.

The above selection criteria resulted in a short list of equipment categories comprised of cable skidders, grapple skidders, feller-bunchers, mobile wood chippers, and for transportation equipment, standard semi-trailer chip vans. A selection of makes and sizes of equipment in each

of these categories was evaluated for production capacity, total daily cost of production and unit cost of production as described in detail for each category in the following subsections. These machines and the accompanying production and economic data formed the database from which choices were made to design the alternative harvesting system configurations as described in section 4.

3.1 Equipment Costing Method

A cost analysis was performed for each machine to establish fixed cost, operating costs including operators wages, and total daily cost of ownership + operation for various levels of machine utilisation. The latter quantity is referred to hereinafter as total operating cost. Major assumptions of this analysis were ;eight hours scheduled operation per working day ;200 scheduled operating days per year ;straight line depreciation over the estimated useful life of equipment which was typically 5 years ;and a 15% before-tax return on investment for equipment owned by the harvesting system operator. A microcomputer based spreadsheet application program called "MACHINE" was written to perform the calculations to determine these and the necessary intermediate quantities. The kernal spreadsheet program was "PerfectCalc"."MACHINE" was run on a KayPro II microcomputer in a CP/M operating system environment. The program was interactive, so input data was readily updated for repetitive program runs. Program runs for many combinations of different and systematically varied values of input data for the harvesting machines were performed and were used to test the sensitivity of total daily cost to different parameters, and specific parameter values.

Figure 1. illustrates the costing procedure by showing an example printout of "MACHINE" for the cost analysis on a Hawker Siddeley Canada Inc. Tree Farmer C4D Cable Skidder for one set of input values. For each machine, the operating cost was comprised of a maintenance & repair allowance, fuel cost, oil & lubricants cost, and tire cost, all on a per productive hour basis as illustrated in figure 1. The inputs determining the value of fixed cost were machine purchase price, estimated useful life, scheduled annual use (hours), estimated salvage value, and average annual utilisation. The result for fixed cost was computed per scheduled hour, and with application of a

Figure 1
Example Printout of
Spreadsheet Computer Program "MACHINE" For Calculating
Machine Rate ($/Hr.) and Unit Production Cost

Machine Name		
Manufacturer	Hawker Siddeley	
Model	Tree Farmer C4D	
Power Rating	54 KW Net	
Input & Calculated Values		
Purchase Cost	55000.00	$
Tire Cost New	5800.00	$
Total Initial Investment (P)	49200.00	$
Tire Life in Hours	2500.00	Hours
Salvage Value (% of P)	20.00	%
Salvage Value (S)	9840.00	$
Estimated Machine Life (N)	5.00	Years
Scheduled Working Days Annually	200.00	Days
Scheduled Hours Per Working Day	8.00	Hours/Day
Scheduled Hours/Year	1600.00	Hrs./Year
Estimated Annual Utilisation Factor (U)	90.00	%
Productive Hours/Day	7.20	PH/Day
Productive Hours/Annum	1440.00	PH/Year
Average Value of Investment (AVI) $(AVI) = \frac{(P-S)x(N-1)}{2N} + (S) =$	33456.00	$/Year
Fixed Cost		
Depreciation (D) $= \frac{P-S}{N}$	7872.00	$/Year
Interest	15.00	%
Insurance	2.00	%
Taxes	0	%
Total Interest, Insurance, Taxes (T)	17.00	%
Total Interest, Insurance, Taxes = (T) x ((AVI)	5687.52	$/Year
Total Fixed Cost Per Annum	13559.52	$/Year
Fixed Cost Per Scheduled Hour	8.47	$/SH
Fixed Cost Per Productive Hour (A)	9.42	$/PH
Operating Costs		
Maintenance & Repair Allowance = % of $\frac{(P-S)}{N \times PH}$	60.00	%
Fuel Consumption at 100% Utilisation	3.28	$/PH
Fuel Consumption at Specified Utilisation	8.20	L/PH.
Fuel Cost Factor (Tax Exempt Diesel)	7.40	L/SH
Fuel Cost	0.43	$/Liter
Oil & Lubricants Cost at 10% of Fuel Cost	3.52	$/PH
Tire Cost = $\frac{1.15 \times \text{Total Tire Cost}}{\text{Total Tire Life in Hours or Miles}}$	0.35	$/PH
Operating Cost Per Productive Hour (B)	2.67	$/PH
	9.82	$/PH
Results		
Machine Rate Excluding Labour (A+B)	19.60	$/PH
Operator Labour Cost	8.00	$/SH
Operator Labour Cost per Productive Hour	8.89	$/PH
Machine Rate Including Operator Labour Cost	28.13	$/PH
Total Daily Operating Cost	202.70	$/Day
Estimated Productivity - Tonnes Per Prod. Hr.	5.10	T/PH
Total Production - Tonnes Per Day	36.72	T/Day
Unit Production Cost	5.52	$/Tonne

utilisation factor, was obtained on a per productive hour basis. The operating cost result was initially estimated on the basis of $/productive hour at 100% utilisation. For other values of utilisation, operating cost was computed as the multiple of operating cost per productive hour x the productive hours/scheduled hour which was proportional to the utilisation factor applied. For operators wages, a value of $8.00 per scheduled hour was used consistently for the machine operators.

The result of the aggregate of fixed cost, operating cost, and machine operator wages as determined by "MACHINE" was a rate in $/productive hour that was, in each case, the basis for total daily machine cost, and unit production cost. Productive hours per day times machine rate yielded total daily machine cost and in every instance corresponded to a set utilisation. In the program, the total daily machine cost result depended on utilisation because of variation of daily operating cost with utilisation, as is the case in actual operations.

Iterations of "MACHINE" were run for each machine for the input values most significantly affecting the results, or about which there was the greatest uncertainty or variability in practice, such as equipment utilisation. By noting the effect on the results of total daily operating cost, daily production, and unit production cost, insight was obtained into the potential use and economics of the machine when operating in a harvesting system of predetermined capacity.

The results obtained from "MACHINE" for each particular harvesting machine alternative considered in the study are tabulated and discussed in the subsections which follow.

3.2 Cable Skidders

The rate of production of a cable skidder operating on whole trees will depend on a variety of factors including the following.

(1) the skidder load capacity
(2) stand average diameter (DBH)
(3) stand density
(4) skidding distance
(5) terrain and weather conditions
(6) operator experience and motivation
(7) applied maintenance schedule.

As a result, cable skidder productivity varies widely in practice, depending mostly on the circumstances of each site, as well as on machine capacity and the skill and experience of the operator.

In considering cable skidders for possible inclusion in 25, 50 and 100 tonne/Day harvesting systems, the practical requirement was to determine the likely variation of production for each machine over the typical range of varying site conditions, and to then select the machine(s) which best matches the proposed harvesting system capacity over this range of conditions.

Analyses using program "MACHINE" indicated that machine purchase price, estimated production rate, and utilisation, are the most signifcant factors affecting unit production costs, given reasonably realistic constant values of other factors. Therefore, attention was focused on obtaining representative sets of values of these most significant parameters. Representative constant values were used for actual values for the other required inputs to the program as estimated from available machine specifications and operations data. Quotations were requested of equipment vendors for low to medium power cable skidders to obtain accurate purchase prices for 1984-1985. Table 3.1 lists the seven small to medium sized cable skidders models for which quotations were obtained. Production rates were based on available data from actual full tree harvesting system operations. Table 3.1 indicates the production rate determined for each machine when skidding whole trees an average distance of 300 m. in a whole tree chip harvesting system for 100% utilisation. Appendix A. contains the specifications or brochures obtained from the vendors for the cable skidders indicated in Table 3.1.

Table 3.1
Estimated Production Capacities at 100% Utilisation
For Low to Medium Power Cable Skidders
When Skidding Whole Trees in Various Stand Conditions

Skidder Make & Model	Power Rating	Average Stand Diameter (DBH) 15 cm.	25 cm.	35 cm.
	(KW Net)	Skidder Production Capacity (Green Tonnes/Prod. Hour)		
Tree Farmer C4D	54	5.1	7.6	10.0
John Deere 440-D	60	5.8	8.4	11.1
John Deere 540-D	67	6.5	9.5	12.5
Clark 664-D	67	6.5	9.5	12.5
Tree Farmer C5D	67	6.5	9.5	12.5
Tree Farmer C6D	87	8.5	12.3	16.2
Caterpillar 518	90	8.7	12.6	16.6

Figure 2.

Cable Skidder Productivity vs. Utilisation
For a Tree Farmer C4D Cable Skidder
In Various Stand Conditions

Utilisation (%)	Production Rate (Tonnes/Day)	Total Daily Operating Cost ($/Day)	Unit Production Cost ($/Tonne)
15 cm. = stand average diameter (DBH)			
30	12.2	155.43	12.70
40	16.3	163.61	10.03
50	20.4	171.19	8.39
60	24.5	179.06	7.31
70	28.6	186.94	6.55
80	32.6	194.82	5.97
90	36.7	202.70	5.52
100	40.8	210.58	5.16
25 cm. = stand average diameter (DBH)			
30	18.2	167.02	9.16
40	24.3	179.06	7.36
50	30.4	190.50	6.27
60	36.5	202.23	5.54
70	42.6	213.97	5.03
80	48.6	225.71	4.64
90	54.7	237.46	4.34
100	60.8	249.20	4.10
35 cm. = stand average diameter (DBH)			
30	24.0	178.14	7.42
40	32.0	193.89	6.06
50	40.0	209.04	5.23
60	48.0	224.47	4.68
70	56.0	239.92	4.28
80	64.0	255.37	3.99
90	72.0	270.82	3.76
100	80.0	286.27	3.58

Basis of Table

Production Capacity at 100% Utilisation
and 300 m. average skidding distance as follows

At 15 cm. average stand DBH = 5.1 tonne/ph
At 25 cm. average stand DBH = 7.6 tonne/ph
At 35 cm. average stand DBH = 10.0 tonne/ph

Fixed Cost + Operator wages = 131.80 $/Day

Considering the production figures shown in Table 3.1 cable skidder production capacity is expected to increase as stand average tree diameter increases. Where tree average diameter is greater, fewer trees need be handled to make up a skidder load. Therefore, less time need be spent choking and decking as, on average, the same time is required to choke and release a full tree regardless of diameter if it is in the range 10-40 cm. As a result more time is available for actual skidding in the skidder production cycle and more cycles can be obtained each hour in stands of larger average stand dbh.

The production rates of Table 3.1 were used as input to the computer program "MACHINE" to determine cable skidder total daily operating cost, daily production, and unit cost of production at 100% utilisation and at 10% intervals down to 30% utilisation. Figure 2 is an example showing the complete set of results as determined for a Hawker Siddeley Tree Farmer C4D skidder. Note that in the case of each stand, operating cost decreases with decreasing utilisation, however not in proportion to the decrease in production. Consequently, unit skidding cost increases with decreasing utilisation, especially below 60% utilisation, and due mostly to the fixed cost base. It is noteworthy that for a given stand, unit production cost is relatively insensitive to utilisation for values between 80-100%.

Figure 2 also illustrates the effect of the cable skidder operating as a component in a harvesting system which encounters varying stand conditions but where the system capacity is constrained to a fixed value. For example, in a system producing about 25 tonne/day in a stand of average DBH of 15 cm., utilisation (U) for the skidder as per figure 2.1 would equal about 61%. In the same system, in stands of 25 cm. and 35 cm. average DBH, skidder U would equal 41% and 31% respectively at 25 tonne/day because the skidder is capable of greater production per productive hour in these stands. The total daily operating cost and therefore the unit production cost are the same at 25 tonne/day for the different stand conditions since the same amount of biomass is skidded in each case.

The results in Figure 2 indicates that in a 25 tonne/day system, the Tree Farmer C4D skidder would produce at a unit cost of about $7.20/tonne. It is also indicated that this skidder would not be expected to be suitable for a

50 tonne/day system in stands less than about 25cm average DBH.

An analysis as described in Figure 2 was performed for each cable skidder indicated in Table 3.1 using each machines corresponding production estimates and costing figures. A summary of the results obtained from these analyses is presented in Table 3.2.

Considering these results, it is evident that a 25 tonne/day whole tree chip harvesting system would require only a single, low power rated (approximately 50 to 70 KW) cable skidder for the skidding function. The unit skidding cost would be relatively high (in the region of $7.20 to $9.50 per green tonne) because of low utilisation of the cable skidders capacity in stands of average DBH between 10-35 cm., ie. a basic mismatch between the 25 tonne/day system and the machines' capacities.

Furthermore, the results shown in Table 3.2 indicate that a single cable skidder with a power rating of 67 KW appears to be well matched to a 50 tonne/day whole tree chip harvesting system when operating in stands of average DBH ranging between 10-35 cm. Unit production costs could be expected to be in the range of $4.60 to $5.60 per green tonne. For a 100 tonne/day harvesting system, two low-medium power rated cable skidders would be required. Several combinations with different power ratings would be possible. For example two identical skidders of 67 Net KW power rating would result in unit skidding costs of about $4.80 to $5.80 per green tonne depending on the particular machine used. Or an alternative arrangement would be a 54 Net KW machine (Tree Farmer C4D) combined with an 87 or 90 KW machine (Tree Farmer C6D or Caterpillar 518). This combination would appear to offer some advantage over two similar sized machines since in stands of high average DBH the large machine alone could produce 100 tonne/day. Presuming the system operator would layup the small skidder for these sites, and thus only have to carry the fixed cost of the small skidder during these times, then unit production costs of about $4.10/tonne could be realised. Alternatively, a single large skidder in the 120 Net KW class could be used, or the system operator could purchase only a single 87 or 90 Net KW machine and restrict operations to stands of average DBH above 25 cm. Obviously, a number of options exist for arranging the skidding function in a 100 tonne/day harvesting system.

Table 3.2
Summary of Results
Analysis of Cable Skidder Unit Production Cost & Utilisation
In 25, 50, and 100 Tonne/Day Whole-Tree Harvesting Systems

Skidder Make And Model	Power Rating (KW Net)	Total Daily Cost Of Operating ($/Day)	Skidder Production Rate (Tonne/Day)	Unit Production Cost ($/Tonne)	Range of Utilisation Over Expected Stand Conditions* (%)
Tree Farmer C4D	54	180	25	7.20	31 - 61
		228	50	4.56	62 - 122
John Deere 440-D	60	211	25	8.44	29 - 54
		261	50	5.22	56 - 108
John Deere 540-D	67	238	25	9.52	25 - 48
		289	50	5.78	50 - 96
Clark 664-D	67	198	25	7.92	25 - 48
		244	50	4.88	50 - 96
Tree Farmer C5D	67	194	25	7.76	25 - 48
		240	50	4.80	50 - 96
Tree Farmer C6D	87	256	50	5.12	39 - 73
Caterpillar 518	90	279	50	5.58	38 - 72

* Expected stand conditions are stand average diameter (DBH) ranging between 15 and 35 cm. and densities of 100 to 200 tonne/ha.

3.3 Mobile Whole Tree Chippers

In general chippers may be classified as either disc or drum/cylinder types. Both are available in stationary or mobile arrangements. Amoung mobile chippers, disc chippers are more common because they require less energy to chip at a given capacity than drum chippers. Furthermore, disc chippers produce chips of more uniform geometry, size, and size distribution than drum chippers. Therefore, when chips are to be used for fibre, chip quality requirements can be met only by mobile disc chippers. For the above reasons, and since chips for fibre have higher value than chips for fuel, only mobile disc chippers were considered in the study.

A comprehensive survey of mobile wood chippers manufactured worldwide was prepared in 1980[8]. In this survey, all identified models were placed in one of six classes as follows; (1) brush chippers (2) three point hitch mounted chippers intended as farm tractor attachments (3) trailer mounted, light weight (4) trailer mounted, medium weight (5) trailer or truck mounted, heavy weight, and (6) terrain chippers. A review of these chippers was performed for the study. This review indicated that only the two larger trailer classes contained likely candidates for 25, 50, and 100 tonne/day harvesting systems. A shortlist of chippers was produced from these two classes by applying the following criteria for selection. The chipper (a) ;had to be readily transportable over public highway (b) ;had to have a disc type chipper with an onboard prime mover and a loader for mechanized feeding of material (c) ;had to be of North American manufacture for reasonable spare parts availability and service as well as a possibility of economical factory overhaul, and (d) ;had to have a record of use by forestry contractors. The application of these criteria resulted in the selection of five chippers, all made by two manufacturers, either, Morbark Industries Inc. of Winn, Michigan, or Strong Manufacturing Company of Remus, Michigan (Trademark - Trelan Chippers). The chipper makes and models are identified in Table 3.3.1. Specifications or brochures as obtained from vendors are provided in Appendix B. A sixth chipper, the Trelan 23-L, is referred to in Table 3.3.1 and is included to illustrate the economy of unit production cost with larger chippers, as discussed later.

Table 3.3.1
Estimated Production Capacities
Of Selected Mobile Whole-Tree Chippers

Chipper Make And Model	Gross Power Rating (KW)	Disc Speed (RPM)	Knife Cuts Per Disc Revolution (Cuts/Rev.)	Infeed Rate [1] (Meter/Min.)	Power Limited Capacity (Tonnes Per Prod. Hour)	Estimated Practical Capacity [3] (Tonnes Per Prod. Hour)
Trelan C-14	75	625	1	11.9	8.7	4.4
Morbark Super Beever	157	850	2	32.4	17.0	8.8
Morbark Model 20	261	738	2	28.1	30.7	15.3
Trelan D-60 [2]	237	625	2	23.8	27.8	13.9
Trelan DL-18	237	625	2	23.8	27.8	13.9
Trelan 23-L	485	650	3	37.1	56.9	28.5

[1] Based on knife setting for 1.9 cm. (3/4") chip length.
[2] Same as Trelan DL-18 except without chipper mounted loader.
[3] Used as input to program "MACHINE" for production capacity a 100% utilisation.

Table 3.3.2
Summary of Results
Analysis of Unit Production Cost & Utilisation of Mobile Chippers
In 25, 50, and 100 Tonne/Day Whole Tree Chip Harvesting Systems

Chipper Make And Model	Gross Power Rating (KW)	Total Daily Cost Of Operating ($/Day)	Chipper & System Production (Tonne/Day)	Unit Production Cost ($/Tonne)	Chipper Utilisation Factor (%)	Infeed Chute Limiting Dimension (cm.)	Estimated Power Limited Diameter Capacity * (cm.)
Trelan C-14	75	246	25	9.84	71	48	31 [1]
Morbark Super Beever	157	219	25	8.76	36	51	27
						51	38 [1]
Morbark Super Beaver	157	261	50	5.22	71	51	27
						51	38 [1]
Morbark Model 20	261	470	50	9.40	41	51	37
Trelan D-60 [2]	237	294	50	5.88	40	46	39
Trelan DL-18	237	404	50	8.08	45	46	39
Trelan 23-L	485	496	50	9.92	22	58	44 [3]
Trelan D-60 [2]	237	368	100	3.68	80	51	37
Trelan DL-18	237	501	100	5.01	90	46	39
Trelan 23-L	485	581	100	5.81	44	58	44 [3]
Morbark Model 20	261	572	100	5.72	82	51	37
Trelan 23-L [4]	485	750	200	3.75	88	58	44 [3]

[1] 1 Full Width Knife Cut Per Disc Revolution
[2] Same as Trelan DL-18 except loader excluded
[3] 3 Full Width Knife Cuts Per Disc Revolution
[4] Trelan 23-L in 200 tonne/day system illustrates economy of scale realised with large capacity chippers.
* Estimated diameter capacity based on 2 full width knife cuts per revolution except as noted otherwise.

The designation of chippers for use in the 25, 50 and 100 tonne/day harvesting systems was based on a sequence of analyses.

First, the practical production capacity of each chipper was estimated. Comparison of manufacturers capacity figures with actual figures from monitored harvesting operations[5,7,13] shows that actual production rates are typically considerably less than quoted capacities. Analyses were performed, based on published values of specific chipping energy[17], to predict chipper production capacity, and indicated that manufacturers typically report the power limited capacity or capacity under ideal conditions of feed logistics, material diameter, knife sharpness, and other conditions, for sales purposes. In actual harvesting operations, these ideal conditions and production capacities are seldom realized.

The practical capacity of each chipper was estimated as follows. A value of specific chipping energy of 6.3 $Kw/m^3/hr$. was determined from published figures to be representative of the power limited capacity of mobile disc chippers under average field conditions. The resulting volumetric capacities (m^3/hr) for the chippers were converted to tonnes/hour using a solid green wood density of 744 Kg/m^3 as an average for all Acadian forest region hardwood and softwood species. The power limited capacity results are shown in Table 3.3.1 for the six chippers. These compare well with the manufacturers' quoted capacities. Next practical capacities were estimated at approximately half the power limited capacities as also shown in Table 3.3.1. When production data was available from monitored harvesting system operations for any of these, or similar sized chippers[5,7,13], actual production capacities compared well with the estimated practical capacities of Table 3.3.1.

For each chipper, the second part of the evaluation consisted of the following.The practical production capacity figure of Table 3.3.1 was used as the input value to program "MACHINE" for the production rate corresponding to 100% utilisation for each chipper. Once other necessary data on each chipper was input to the program, such as purchase cost, and fuel use per productive hour, etc., successive runs of the program at 10% increments of utilisation were made to determine a matrix of utilisation, total daily cost of operation, daily production, and unit cost of production, for each chipper. Sets of results for each chipper were then

interpolated from this matrix of values for production rates of 25, 50, and 100 tonne/day. Table 3.3.2 presents the results that were obtained for the six chippers when operating in 25, 50 and 100 tonne/day harvesting systems. Obviously inappropriate matches of systems and chippers have been ommitted from the Table for clarity.

Considering Table 3.3.2, comparison of the results of unit production cost and chipper utilisation for the various systems and chippers indicates that only two chippers are suitable for a 25 tonne/day system. Unit production costs will be relatively high at about $8.70 to $9.80/tonne.

For a 50 tonne/day system, Table 3.3.2 indicates that the Morbark Super Beever chipper is well matched. A unit production cost of about $5.20/tonne at a utilisation of about 70% would be expected. The Morbark 20, and the Trelan D-60, DL-18, and 23-L chippers would not be well utilised in a 50 tonne/day harvesting system as indicated by the higher unit production costs of about $8.00-$10.00/tonne and low utilisations ranging from only 22% to 45%. These chippers would be more suited to a 100 tonne/day system where they would yield unit production costs in the area of $5.00 to $5.80/tonne. Note in Table 3.3.2 that for the Trelan D-60, unit production costs should not be compared because the cost of a loader is not included. The Trelan D-60 has been included to allow for the case of a system where the operator already has a loader which could be used to feed the chipper. The results for the large Trelan 23-L chipper were produced, and are included in Table 3.3.2 to illustrate the economic advantages of a larger chipper. Even at a low utilisation of 44% in a 100 tonne/day harvesting system, it yields a unit production cost comparable to that of smaller capacity chippers at higher utilisation in the same system. However, even more significant, at comparable utilisation, eg. Trelan 23-L at 88% in a 200 tonne/day system, a much better unit cost is obtained at $3.73/tonne. This case illustrates the economic reasoning behind operators preference for large scale chippers and harvesting systems.

Table 3.4.1
Estimated Production Capacities at 100% Utilisation
For Grapple Skidders

Skidder Make & Model	Power Rating (KW)	Estimated Production Capacity At 100% Utilisation In Clearcutting Operation (tonnes Per Prod. Hour)	(tonnes per 8 Hour Shift)
John Deere 448-D	60	16.0	128
John Deere 540-B	67	17.7	142
Clark 665-D	86	23.0	184

Table 3.4.2
Summary of Results
Analysis of Unit Production Cost & Utilisation for Grapple Skidders
In 50 and 100 Tonne/Day Whole Tree Chip Harvesting Systems

Grapple Skidder Make And Model	Gross Power Rating (KW)	Estimated Total Daily Cost Of Operating * ($/Day)	Skidder & System Production (Tonne/Day)	Estimated Unit Production Cost ($/Tonne)	Skidder Utilisation Factor (%)
John Deere 448-D	60	242	50	4.84	39
John Deere 540-B	67	268	50	5.36	35
Clark 665-D	86	240	50	4.80	27
John Deere 448-D	60	296	100	2.96	78
John Deere 540-B	67	324	100	3.24	71
Clark 665-D	86	288	100	2.88	54

* Estimates of operating cost include operator wages but not employers' overhead for operator.

3.4 Grapple Skidders

Grapple skidders are available in a range of sizes at power ratings ranging between 60 and 140 KW. Production is primarily a function of power rating, all other factors being equal. In general, larger machines can support larger grapples, and pull heavier loads over more difficult terrain. Physical dimensions, weight, and price increase with power rating. Some disadvantages of large machines, increasing in proportion with physical dimensions and weight, are that more room is required for maneouvering, resulting in greater residual stand damage. Greater ground disturbance is also more likely, with a larger machine.

Experience in harvesting system operation[3,5] indicates that one large grapple skidder is capable of 150-300 tonne per 8 hour shift depending on skidding distance, and system constraints. The smallest grapple skidders are therefore indicated for the subject small scale harvesting systems.

Table 3.4.1 identifies the three small grapple skidders which were determined to be representative machines for small scale harvesting systems. Appendix C. presents the specifications or brochures for these machines as obtained from equipment vendors.

The production capacities of the small grapple skidders at 100% utilisation were projected from available data on large grapple skidders by considering load size as proportional to grapple full-open area and net horsepower. The results obtained are shown in Table 3.4.1. These values of production capacity were then used as input to the computer program "MACHINE" to obtain results of unit production cost, utilisation and total daily cost. These results are summarized in Table 3.4.2. As indicated by these results, the production capacity of small (60-86 KW) grapple skidders spans both 50 and 100 tonne/day harvesting systems. However, even the smallest grapple skidders are not well matched to a 50 tonne/day harvesting system, because utilisation would be low (27% to 39%). Unit skidding costs as determined would be about $4.80 to $5.40/tonne. The results for 100 tonne/day in Table 3.4.2 indicate that small grapple skidder capacity is best matched to a 100 tonne/day system where utilisations of 78% and 71%, respectively, correspond to unit costs of $2.96 and $3.24 per tonne. The

seemingly anomolus unit cost results for the Clark 665-D skidder (larger machine at lower utilisation producing the lowest unit production cost) is due to the effect of different purchases prices. Quoted prices for the machines were JD 448-D = $95,000, JD 540-B = $113,500, and Clarke 665-D = $99,000 indicating more capacity and power per dollar for the Clark skidder and thus lower unit production cost for equivalent conditions.

3.5 Feller-Bunchers

The feller-buncher, together with grapple skidding, represents completely mechanized whole-tree chip harvesting. In areas where slope, terrain, and tree size are suitable, the feller-buncher system is generally considered preferable to cable skidder systems, because of the greater volume or weight which can be removed and because of the smaller trees and lower density stands that can be operated.

A typical feller-buncher is comprised of two main components - a prime mover-carrier, and an hydraulically powered shearing head.

Prime movers can be either tracked or wheeled and are usually adaptations of fixed frame or articulated wheeled loaders, crawler tractors, or tracked excavators. Equipment manufacturers offering machines for feller-buncher prime mover duty are many and include Caterpillar, Hydro-Ax, International, John Deere, TimberJack, Franklin, Pettibone, Case (Drott), Morbark and Koehring. In some cases, but typically in the largest power rating category, dedicated feller-buncher designs are offered, for example the John Deere 743-A feller-buncher/tree harvester and the Forano model BJ-20.

Shearing heads come in a range of sizes designated according to their maximum diameter capacity. Examples of manufacturers and model designations are Fleco (15" and 20"), AMEC also known as Rome (14" and 20"), and Morbark (10", 13", 17", and 22"). As the maximum diameter capacity sometimes corresponds to softwood with reduced capacity when operating hardwoods, and other times it implies hardwood capacity, care is required in considering diameter capacity specifications. Most shear designs now include an accummulator feature which allows a number of trees, depending on their diameter, to be cut and held before dropping the multi-stem load. This is

an important feature for maintaining feller-buncher production capacity over a variety of stand conditions, especially when stand average diameter is low.

Prime mover manufacturers usually recommend a specific make and model of shear head for their particular prime mover models to ensure compatibility of mechanical connection, hydraulic requirements, and - within reason - machine stability.

The production capacity of feller-bunchers will depend on a variety of factors, such as stand density and average diameter, cutting prescription, terrain and soil conditions, and snow depths, as well as the machines characteristics. In general, provided larger trees are available, machines capable of shearing larger trees can be expected to have higher production because of higher volume and weight per piece handled.

A single large or medium sized feller buncher is capable of producing 200 plus tonnes per 8 hour shift in mechanized thinning and clearcutting operations[3,5,7,13]. Small size feller-bunchers were therefore indicated for harvesting systems of 100 tonne per day production and lower. Review of available small size machines showed there to be little significant difference in the large number of small prime movers and the several makes of shears. Therefore several representative small wheeled and tracked feller-bunchers were selected for production and cost analysis. These machines are listed in Table 3.5.1. The specifications or brochures obtained from vendors for these prime movers and shears are provided in Appendix D. Analyses were made to estimate a representative production capacity for each of these feller-bunchers in a clearcutting operation. Table 3.5.1 shows the results that were obtained in each case. These values were then used as the basis for production rate, total daily operating cost, and unit production cost analysis over a range of utilisations from 30-100% using the computer program "MACHINE". Sets of values were then interpolated for each feller-buncher producing in 50 and 100 tonne/day harvesting systems. A summary of these results is presented in Table 3.5.2. The utilisation values in Table 3.5.2 illustrate that even the smallest feller-bunchers are best matched to a 100 tonne/day harvesting system, and are less suitable for a 50 tonne/day or lower capacity system. Low utilisation of machine capacity in 50 tonne/day systems (35-45%), result in unit production costs between $4.60

Table 3.5.1
Estimated Production Capacities at 100% Utilisation
For Selected Feller Bunchers

Prime Mover And Shear	Net Power Rating (KW Net)	Estimated Production Capacity At 100% Utilisation In Clearcutting Operation	
		Tonnes Per Prod. Hour	Tonnes Per 8 Hour Shift
Wheeled Prime Movers			
Caterpillar 910 38 cm. (15") Fleco	48	14.6	117
Caterpillar 920 50 cm. (20") Fleco	60	18.0	144
John Deere 544-C 50 cm. (20") AMEC-SH	82	24.8	198
Tracked Prime Movers			
Caterpillar 931 38 cm. (15") Fleco	46	14.0	112
John Deere 555-A 50 cm. (20") AMEC-SH	58	17.6	141

Table 3.5.2
Summary of Results
Analysis of Unit Production Cost & Utilisation of Selected Feller/Bunchers
In 50 and 100 Tonne/Day Whole-Tree Chip Harvesting Systems

Prime Mover And Shear	Gross Power Rating	Total Daily Cost Of Operating	Machine & System Production	Unit Production Cost	Machine Utilisation Factor	Diameter Capacity of Shear	
						Hardwood	Softwood
	(KW)	($/Day)	(Tonne/Day)	($/Tonne)	(%)	(cm.)	(cm.)
Wheeled Prime Movers							
Caterpillar 910	48	248	50	4.97	43		
38 cm. (15") Fleco		301	100	3.01	86	30	38
Caterpillar 920	60	287	50	5.74	35		
50 cm. (20") Fleco		339	100	3.39	69	43	50
John Deere 544-C	82	375	100	3.75	50	51	51
50 cm. (20") AMEC-SH							
Tracked Prime Movers							
Caterpillar 931	46	228	50	4.56	45		
38 cm. (15") Fleco		271	100	2.71	89	30	38
John Deere 555-A	58	306	50	6.12	35		
50 cm. (20") AMEC-SH		354	100	3.54	71	51	51

and $6.10 per tonne, considerably higher than in a 100 tonne/day system, where utilisation is (69%-89%) yielding unit production costs between $2.70 and $3.75 per tonne. It should be noted that the John Deere 544-C with 50cm. shear is somewhat oversized for a 100 tonne system as indicated by a utilisation of only 50% and a unit production cost at the high end of $3.75/tonne for 100 tonne/day production. This machine would be more effectively used in a system producing more than 100 tonne/day.

3.6 Transportation Equipment

The small scale harvesting system operator will require equipment for transporting wood chips to the purchaser over public highways. Standard forest industry equipment for this purpose is the conventional semi-trailer van hauled by truck tractor.

The system operator may consider other possible equipment options but these would seldom be competitive. The unit cost of transporting wood chips is sensitive to load capacity and transport distance. Therefore, vehicles with lower capacity than semi-trailer vans result in high unit transportation costs, and are not competitive, except for very short haul distances. Higher capacity equipment, such as very long articulated trailers and "pup" trailers, can also be ruled out. These designs are intended for transporting sawmill residues and wood chips. Consequently, they are of open top design intended for loading from overhead hoppers and are unsuitable for pneumatic loading directly from mobile whole tree chippers. More important, these articulated units are too cumbersome for maneouvering on landings and on the minimal roads which can be expected on many private woodlots.

For the present study, consideration was restricted to standard semi-trailer chip vans for the purpose of sizing and costing the transportation function in the harvesting system operations.

Semi-trailer chip vans used for whole tree chipping operations vary in length from about 12.2 m. (40 ft.) to as high as 16.8 m. (55 ft.). For economy of unit transportation cost, the trend in new designs is to longer lengths with more axles to enable increased volume and weight capacity per

trip within highway load limits. Dropped floors are another design feature appearing in order to maximize capacity. Harvesting system operators use units ranging from converted freight vans to newly manufactured units produced specifically for the purpose. Closed tops are required to contain chips as they are blown directly from the mobile chipper discharge chute into the vans' back end. And screened openings on the upper sides are needed to ventilate the chipper air discharge to allow the van to completely fill.

The volumetric capacity of semi-trailer chip vans ranges between about 80 m^3 and 110 m^3 depending mainly on the length. The bulk density of green wood chips at 40% solid volume content varies between average values of 260 $Kg./m^3$ for softwood species to 320 $Kg./m^3$ for hardwood species. For mixtures of hardwoods and softwoods, as would occur when harvesting whole tree chips for fuel, actual bulk density could range anywhere between the above two values depending on the proportions of each in the mixture. Representative intermediate values would be 275 $Kg./m^3$ for 25% HW & 75% SW, 290 $Kg./m^3$ for 50% HW & 50% SW, and 305 $Kg./m^3$ for 75% HW & 25% SW. Combining these values of bulk density with van volumetric capacities, payloads could range from as low as approximately 20 green tonnes through 35 green tonnes per trip. A range of 25 to 30 tonnes per load was selected as a representative average for use in transportation cost analyses in the study.

In selecting transportation equipment for 25 , 50 and 100 tonne/day harvesting systems, the major considerations involved equipment ownership or contracting, the number of trucks and chip vans required, distance to market, and total and unit transportation costs.

Whether or not the transport equipment should be owned or contracted will depend on specific circumstances such as, the short and long-term availability and reliablilty of suitable contract trucking in the area, and the financial resources of the harvesting system operator. The capital required to set up a harvesting system with owner operated trucking will be considerably greater than if the trucking is contracted. However, contract trucking may result in higher unit costs depending on the pricing structure of the contract trucker, or it may be unavailable on acceptable terms. To have a basis for comparison, cost analyses were performed for both options

as discussed below.

It is evident from the 25-30 tonne per load capacity of standard chip vans that 1, 2, and 4 deliveries per day will be required for nominal 25, 50, and 100 tonne/day harvesting systems respectively. For each system, the number of chip vans and truck tractors needed will depend on the distance to market. Also, total transportation equipment operating costs, and therefore unit transport costs, will vary with distance. A computer simulation program called "TRANCOST" was written to perform transportation requirement evaluations and thus determine the scheduling requirements and costs for transport systems of 1, 2, and 4 deliveries per day for varying delivery distances. Program "MACHINE" was used to obtain representative values of fixed cost per scheduled hour for truck tractor and chip vans as required for input to "TRANCOST".

Figure 3. presents an example printout of "TRANCOST" for a tranport system comprised of 1 truck tractor and 2 chip vans, making two deliveries per day at 100 km. distance. The values of all input parameters necessary for a program run are indicated in the example. The key input parameter values for the program are the market distance, the trips per day, the truck and chip van fixed costs, the number of available truck tractors and vans, the load capacity (25 or 30 tonnes/load), and the values of the costing factors for fuel, etc.. For the conditions of the example, the results indicate that unit transportation costs of $10.80/tonne would be incurred.

Iterations of program "TRANCOST" were run for varying sets of input values to establish truck and van scheduling requirements, total daily costs, unit transportation costs, and transportation system utilisation for the 1, 2, and 4 trips/day at market distances ranging from 20 to 160 km.

Table 3.6.1 presents the results for a single chip van delivery per day where the harvest system operator owns the equipment. As indicated, one truck and two chip vans are sufficient at all distances up to 160 km. However, utilisation is low (13% - 62%) over the total range of market distances and unit production costs are high at $15.84/tonne to $19.76/tonne. Two chip vans are required to avoid chipper delays if hauling coincides with chipping. However, one chip van would be sufficient where some chipper delays could be absorbed (short distances to market) or if

hauling were scheduled before or after other system operations. Results for this alternative improve only slightly over those of Table 3.6.1 yielding a range of $13.80 to $17.70/tonne over the range of distances. A more cost effective alternative for a nominal 25 tonne/day system might be contract of the transport to a trucking firm. A quotation was obtained from R.S. Couglan Ltd. of Fredericton, N.B. to determine representative contract trucking costs. The company quoted provision of one truck tractor with driver and one chip van at the following rate structure - A minimum of $175 for one round trip or $1.70/km. (one way distance to market) which ever is greater. In addition, the terms required that the harvest system operator provide a second chip van to facilitate the contractors scheduling. To hire the same services for eight scheduled hours/day, regardless of the number of trips, would be a minimum of $450.00/day or $1.70/km which ever is greater. The latter provided the basis for costing contract trucking for more than 1 trip per day as discussed later. Table 3.6.2 presents the results for the one trip per day with contract trucking. Unit production costs ranging between $9.60 and $14.00/tonne for 25 tonne/load would be realized. Thus, in a nominal 25 tonne/day harvesting system, contracting appears to be the better economic alternative than harvest system operator ownership of transportation equipment.

Table 3.6.3 presents the results obtained for a nominal 50 tonne/day transportation system where the system operator owns the transport equipment. These results indicate that 1 truck and 2 chip vans is sufficient for the system over the total range of market distance without imposing chipper delays. Utilisation is double that for a 25 tonne/day system, ranging between 26% at 20 km. market distance to over 100% for distances above 120 km. (ie. overtime required to complete the trucking at these distances.) Unit production costs, at $8.55 to $13.10/tonne, are considerably lower than for the case of a 25 tonne/day system.

Table 3.6.4 presents the results for the alternative of contract trucking in a 50 tonne/day system. Comparing with Table 3.6.3 the effect of the contractors' rate structure yields slightly higher unit production costs for distances up to about 80 km. and slightly lower unit costs for 80 to 160 Km.. The availability of capital, and other circumstances would be the deciding factors in choosing between these two possible alternatives for an

Figure 3.
Example Printout of
Spreadsheet Computer Simulation Program
"TRANCOST"
For Determination of Total and Unit Cost
Of Wood Chip Transportation in Standard Chip Vans

Input and Calculated Values

Scheduled Truck Operating Time per Day	8.00	Hrs./Day
Average Transportation Speed	72.00	Km./Hr
Average Transportation Speed	45.00	Mph
Time at Delivery Point	0.25	Hrs.
Time at Pickup Site	0.25	Hrs.
One Way Distance to Market	100.00	Km.
One Way Distance to Market	62.14	Mi.
One Way Travel Time	1.39	Hrs.
Round Trip Time	3.28	Hrs.
Round Trips/Day	2	Trips/Day
Total Trucking Time in Day	6.56	Hrs.
Driver Overtime in Day	0	Hrs.
Overtime Hours	0	Hrs.
Pay Overtime? 1.0=Yes 0.0=No	0	
Overtime Hours Paid	0	Hrs.
Truck Fixed Cost Per Schedule Hour	16.25	$/Sch. Hr.
Number of Truck Tractors	1	
Chip Van Fixed Cost Per Scheduled Hour	6.38	$/Sch. Hr.
Number of Chip Vans	2	
Total Fixed Cost Per Sch. Hour	29.01	$/Sch. Hr.

Costing Factors	1 Truck	1 Chip Van	
Maintenance & Repair	4.97	2.22	$/Hr.
Fuel Cost per Mile	0.3960	0	$/Mi.
Fuel Cost per Kilometer	0.2461	0	$/Km.
Oil & Lubricants Charge at 10% of Fuel	0.0246	0	$/Km.
Tire Cost per Mile	0.0652	0.0652	$/Mi.
Tire Cost per Kilometer	0.0405	0.0405	$/Km.
Operator Labour Rate	10.00	0	$/Hr.
Operator Overtime Rate at 1.5 times	15.00	0	$/Hr.

Calculated Costs	Totals	1 Truck	1 Van
Total Daily Fixed Cost	232.08	130.00	51.04
Daily Main. & Repair Allowance	75.28	39.76	17.76
Daily Fuel Cost	98.43	98.43	0
Daily Oil & Lubricants Charge	9.84	9.84	0
Daily Tire Cost	32.41	16.21	8.10
Truck Operator Pay	80.00	80.00	0
Truck Operator Overtime Pay	0	0	0
Employers Employee Cost	12.00	12.00	0
Total Daily Cost Of Ownership + Operation	540.04	386.24	76.90

Overall Results

For Tonnes/Load = 25.00 And Tonnes/Day = 50.00
Unit Transportation Cost = 10.80 $/Tonne

Table 3.6.1
Results of Analysis of Unit Transportation Cost Vs. Distance To Market
For
1 Round Trip/Day - 25 to 30 Tonnes/Day

One Way Distance To Market (Km.)	Total Operating Cost ($/Day)	Required Transport Equipment		Total Travelling Time (Hrs./Day)	Transport System Utilisation (%)	Unit Cost at 25 Tonne/Load ($/Tonne)	Unit Cost at 30 Tonne/Load ($/Tonne)
		No. Truck Tractors	No. Chip Vans				
20	396	1	2	1.1	13	15.84	13.20
40	410	1	2	1.6	20	16.40	13.67
60	424	1	2	2.2	27	16.96	14.13
80	438	1	2	2.7	34	17.52	14.60
100	452	1	2	3.3	41	18.08	15.07
120	466	1	2	3.8	48	18.64	15.53
140	480	1	2	4.4	55	19.20	16.00
160	494	1	2	4.9	62	19.76	16.47

Table 3.6.2
Unit Transportation Cost Vs. Distance To Market
For
1 Round Trip/Day - 25 to 30 Tonnes/Day
And Subcontract of 1 Truck Tractor + 1 Chip Van

One Way Distance To Market (Km.)	Total Cost To System Operator ($/Day)	Required Transport Equipment		Round Trip Travelling Time (Hrs./Day)	Transport System Utilisation (%)	Unit Cost at 25 Tonne/Load ($/Tonne)	Unit Cost at 30 Tonne/Load ($/Tonne)
		No. Truck Tractors	No. Chip Vans				
20	240	1	2 *	1.1	13	9.60	8.00
40	240	1	2	1.6	20	9.60	8.00
60	240	1	2	2.2	27	9.60	8.00
80	240	1	2	2.7	34	9.60	8.00
100	240	1	2	3.3	41	9.60	8.00
120	277	1	2	3.8	48	11.08	9.23
140	313	1	2	4.4	55	12.52	10.43
160	350	1	2	4.9	62	14.00	11.67

* 1 Chip Van owned by harvesting system operator

Table 3.6.3
Results of Analysis of Unit Transportation Cost Vs. Distance To Market
For
2 Round Trips/Day - 50-60 Tonnes/Day

One Way Distance To Market (Km.)	Total Operating Cost ($/Day)	Required Transport Equipment		Total Travelling Time (Hrs./Day)	Transport System Utilisation (%)	Unit Cost at 25 Tonne/Load ($/Tonne)	Unit Cost at 30 Tonne/Load ($/Tonne)
		No. Truck Tractors	No. Chip Vans				
20	427	1	2	2.1	26	8.55	7.12
40	456	1	2	3.2	40	9.11	7.60
60	484	1	2	4.3	54	9.68	8.07
80	512	1	2	5.4	68	10.24	8.83
100	540	1	2	6.6	82	10.80	9.00
120	568	1	2	7.7	96	11.36	9.47
140	611	1	2	8.8	110	12.23	10.18
160	654	1	2	9.9	124	13.09	10.90

Table 3.6.4
Unit Transportation Cost Vs. Distance To Market
For
2 Round Trips/Day - 50-60 Tonnes/Day
And Subcontract of 1 Truck Tractor + 1 Chip Van

One Way Distance To Market (Km.)	Total Cost To System Operator ($/Day)	Required Transport Equipment		Total Travelling Time (Hrs./Day)	Transport System Utilisation (%)	Unit Cost at 25 Tonne/Load ($/Tonne)	Unit Cost at 30 Tonne/Load ($/Tonne)
		No. Truck Tractors	No. Chip Vans				
20	525	1	2 *	2.1	26	10.50	8.75
40	525	1	2	3.2	40	10.50	8.75
60	525	1	2	4.3	54	10.50	8.75
80	525	1	2	5.4	68	10.50	8.75
100	525	1	2	6.6	82	10.50	8.75
120	529	1	2	7.7	96	10.58	8.82
140	576	1	2	8.8	110	11.52	9.60
160	648	1	2	9.9	124	12.96	10.80

* 1 Chip Van owned by the harvesting system operator

Table 3.6.5
Results of Analysis of Unit Transportation Cost Vs. Distance To Market
For
4 Round Trips/Day - 100 to 120 Tonnes/Day

One Way Distance To Market (Km.)	Total Operating Cost ($/Day)	Required Transport Equipment		Total Travelling Time (Hrs./Day)	Transport System Utilisation (%)	Unit Cost at 25 Tonne/Load ($/Tonne)	Unit Cost at 30 Tonne/Load ($/Tonne)
		No. Truck Tractors	No. Chip Vans				
Case 1							
20	456	1	2	4.4	55	4.56	3.80
40	512	1	2	6.4	80	5.12	4.27
Case 2							
20	524	1	3	4.4	55	5.24	4.37
40	581	1	3	6.4	80	5.81	4.84
60	648	1	3	8.8	110	6.48	5.40
Case 3							
20	786	2	3	2.2 x 2	28	7.86	6.55
40	842	2	3	3.2 x 2	40	8.42	7.02
60	899	2	3	4.4 x 2	55	8.99	7.49
80	955	2	3	5.4 x 2	68	9.55	7.96
100	1011	2	3	6.6 x 2	82	10.11	8.43
120	1068	2	3	7.7 x 2	96	10.68	8.90
140	1154	2	3	8.8 x 2	110	11.54	9.62
160	1240	2	3	9.9 x 2	124	12.40	10.33
Case 4							
120	1136	2	4	7.7 x 2	96	11.36	9.47
140	1228	2	4	8.8 x 2	110	12.23	10.19
160	1309	2	4	9.9 x 2	124	13.09	10.90

actual nominal 50 tonne/day operation. Table 3.6.5 presents the results of the transportation analyses performed for a nominal 100 tonne/day harvesting system. Four cases are shown to illustrate the impact of market distance on the required transportation equipment configuration to avoid causing chipper delays because of lack of chip vans.

Case 1 indicates that a system owned by the harvest system operator and comprised of 1 truck and 2 chip vans, would yield unit costs in the region of $4.50 to $5.20 per tonne for operations restricted to a maximum distance of about 40 to 50 Km. from market.

Case 2 illustrates that 1 truck and 3 vans could extend the range to roughly 60 km. in transporting 100 tonne/day. Unit costs would be higher for this configuration of transportation equipment, ranging between $5.20 and $6.50 per tonne. due to the cost of the additional chip van. Case 3 shows that 2 trucks and 3 chip vans could deliver 100 tonnes/day over the complete range of distances up to 160 km. without causing chipper delays. Utilisation of this equipment would be low for short distances to market, however, and unit costs would range from $7.80 to $9.00/tonne for 20-60 km. distances. Utilisation ranging from 55%-96% would be realised for distances between 60 and 120 km. yielding unit costs between $9.00 and $10.70/tonne. For market distances between 120 and 160 km. van scheduling is very tight and any delays in trucking would result in chipper delays. For these market distances many harvest system operators would add a fourth chip van. Case 4 illustrates that unit transportation costs would range from $11.30 to $13.10 over these distances for a transportation system comprised of 2 trucks and 4 chip vans.

Table 3.6.6 presents the complete results for an owner operated system comprised of 2 trucks and 4 chip vans at nominal 100-120 tonne/day delivery.

It is evident from the foregoing that the operator of a nominal 100 tonne/day system will have a number of alternatives for organizing his transportation requirements. For 4 trips/day, the most efficient and flexible choice over distances up to 160 km./day is a 2 truck and 3 chip van system. The tables indicate that unit costs of transportation for the system will range from about $7.80 to $13.10/tonne depending on market

Table 3.6.6
Results of Analysis of Unit Transportation Cost Vs. Distance To Market
For
4 Round Trips/Day - 100 to 120 Tonnes/Day

One Way Distance To Market (Km.)	Total Operating Cost ($/Day)	Required Transport Equipment		Total Travelling Time (Hrs./Day)	Transport System Utilisation (%)	Unit Cost at 25 Tonne/Load ($/Tonne)	Unit Cost at 30 Tonne/Load ($/Tonne)
		No. Truck Tractors	No. Chip Vans				
20	854	2	4	2.1 x 2	26	8.55	7.12
40	912	2	4	3.2 x 2	40	9.11	7.60
60	968	2	4	4.3 x 2	54	9.68	8.07
80	1024	2	4	5.4 x 2	68	10.24	8.83
100	1080	2	4	6.6 x 2	82	10.80	9.00
120	1136	2	4	7.7 x 2	96	11.36	9.47
140	1222	2	4	8.8 x 2	110	12.23	10.18
160	1308	2	4	9.9 x 2	124	13.09	10.90

distance regardless of whether the system is operator owned or contracted.

For an actual operation, the average annual unit transportation cost incurred for operations at different harvesting sites at various distances to market will depend on the weighted average distance to market for the sites. An average value of $9.60/tonne was considered representative for costing 100 tonne/day harvesting systems.

4 Harvesting System Configurations

The harvesting systems were designed on the basis of the production, utilisation, and cost results presented for the machines of the various categories in Section 4.0. To design each system, the most cost effective component machine(s) with the best capacity match was selected for each harvesting system function. Aggegrate total values of system capital cost, total daily cost of operation, and unit production cost were then produced for the system. This information formed the basis for comparison between system alternatives, and in the case of total system unit production cost, for comparison with market prices for determining the economic viability of each system. The final assessment of economic viability was made based on the results of discounted cash flow analysis as presented in Section 5.

The two major design alternatives were (a) systems based on chainsaw felling and cable skidding, and (b) systems based on feller-bunching and grapple skidding. In configuring a system, the only other major design decision was the selection of the size and number of machines to use for each harvesting system function.

For harvesting system operating methods, "hot", or simultaneous and coordinated operation of all system components, is generally recognised as the most efficient procedure for whole tree harvesting system operation, and therefore all harvesting systems were considered to operate in this manner. This does not artifically constrain the scope of system alternatives, since virtually all existing whole tree harvesting systems operate in this way. The principal alternative to "hot" operation is cold decking or stockpiling in which felling and skidding to landing are performed seperately from chipping and transporting. Stockpiling is unsuitable for efficient whole tree chipping on private woodlands because because of the additional expenses incurred in large landing construction, and in piling and unpiling whole trees. Entanglement of stacked whole trees also mitigates against this method. Stockpiling is typically used only on large company land tracts with extensive private road systems where a single large chipper

serves a number of logging operations[3]. As it is, a "hot" operation requires a woods landing of about 0.2 hectare area within a maximum of about 500 m. of the harvesting site to enable chip van maneouvering, effective decking of skidder loads, efficient chipping and thus economic operation.

The following subsections present the optimum harvesting system configurations that were identified in the study. For each system, the results are discussed, especially with regard to the unit cost of production relative to the current market price for whole tree chips for fuel and fibre.

4.1 Nominal 25 tonne/day harvesting system

The optimum configuration determined for a 25 tonne/day system is described in Table 4.1. As shown in the table, the optimum configuration does not achieve effective utilisation of the major system components with the exception of the Trelan C-14 chipper. The system unit production cost of approximately $35.00/tonne exceeds the current market prices of both chips for fiber ($25 to $27/green tonne), and chips for fuel ($14 to $16/green tonne).

A possible economy of operation for this system would be to use one man for both felling and operating the skidder, instead of one man for each function as implicit in the table, since the cutter and skidder utilisation are both less than 50%. If this were achieved while maintaining 25 tonne/day, then the estimated system unit production cost would reduce marginally to $31.48/tonne.

Since there is spare capacity in all component functions in this system, another alternative to improve economic performance would be to increase production to 30 tonne/day. This is within the systems capacity without altering the equipment configuration if chip vans at the high end of their capacity range were used - 110 m^3 per van, allowing 30 tonne/van on average. Rework of Table 4.1 for this case results in an estimated total daily system cost of $880.00/day and a corresponding system unit production cost of $29.33/tonne. If, in addition, one man could both fell and operate the skidder and maintain 30 tonne/day production, then the system unit cost would reduce to $25.20/tonne. This is within range of the market price for

Table 4.1
Capital and Unit Production Costs For a
Nominal 25 Tonne/Day Biomass Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost ($/Day)	Unit Cost ($/Tonne)
Felling - Manual with Chainsaw					
1 Cutters' Chainsaw - Echo Model 650	550.00	25	17	8.00	0.32
1 Chainsaw at Chipper - Echo 650	550.00	-	-	5.50	0.22
1 Cutters' Wages		25	17	64.00	2.56
1 Cable Skidder - Tree Farmer C4D	55000.00	25	46	190.00	7.60
Chipping					
Small Chipper with Grapple Loader Trelan Model C-14	79500.00	25	71	251.00	10.04
Transportation					
Contract of 1 Truck + 1 Chip Van	-			175.00	
1 Chip Van - Valpri or Manac	43000.00			65.00	
Subtotal - Transportation		25	38	240.00	9.60
Micellaneous					
Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	1.60
Landing & Road Construction/Moving	-	-	-	25.00	1.00
Employers' Employee Costs	-	-	-		
15% of wages				40.80	1.63
Workmens' Compensation	-	-	-	15.23	0.61
System Totals	190600.00	25		879.53	35.18

chips for fiber. However, the margin for profitability is small. For example, assuming a selling price of $27.00/tonne and a system unit production cost of $25.20, then for 200 operating days/annum, the net profit margin would be $10,800/annum.

This harvesting system is uneconomical for harvesting fuel chips at current market prices.

It should be noted that for the system described in Table 4.1 the transportation requirement is contracted except for one chip van. If contract trucking cannot be arranged, or is unavailable, under acceptable terms, then the system operator would have to purchase 1 truck tractor and 1 more chip van. In addition to raising the capital cost of the system from $190,000 to $320,000, the unit cost of transportation would increase significantly as indicated by Table 3.6.1 in Section 3.6. Under these circumstances, the system is definitely not cost effective for either fiber or fuel chip harvesting.

All other possible cable skidder system configurations for a nominal 25 tonne/day resulted in significantly higher unit production costs, and capital investment requirements, than the system of Table 5.1.

Similarly, all configurations of feller-buncher plus grapple skidder systems for 25 to 30 tonne/day production were uneconomic due to very low utilisation of equipment capacity and high system production costs.

4.2 Nominal 50 tonne/day harvesting systems

Table 4.2 presents the results obtained for the optimum 50 tonne/day whole tree chip harvesting system. Although utilisation is low at 33% for a single feller, utilisation for other system components is reasonable and well matched at 73% for the one skidder, 71% for the chipper, and 68% for the transportation equipment. Skidder utilisation is high enough to preclude one man from doing both the cutting and the skidding. Unused felling time could be salvaged in several ways however to improve system flexibility, for example by assisting the skidder operator in choking. This would help in maintaining system production where marginal conditions were encountered. The system capital cost of $209,000 indicated in Table 4.2 is for contract of the majority of the transportation equipment. System

Table 4.2
Capital and Unit Production Costs For a
Nominal 50 Tonne/Day Biomass Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost ($/Day)	Unit Cost ($/Tonne)
Felling - Manual with Chainsaw					
1 Cutters' Chainsaw - Echo Model 650	550.00	50	33	13.00	0.26
1 Chainsaw at Chipper - Echo 650	550.00	-	-	8.00	0.16
1 Cutters' Wages		50	33	64.00	1.28
1 Cable Skidder - Clark 664-D	70500.00	50	73	244.00	4.88
Chipping					
Small Chipper with Grapple Loader Morbark Super Beaver	82000.00	50	71	261.00	5.22
Transportation					
Contract of 1 Truck + 1 Chip Van	-			450.00	
1 Chip Van - Valpri or Manac	43000.00			75.00	
Subtotal - Transportation		50	68	525.00	10.50
Miscellaneous					
Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	0.80
Landing & Road Construction/Moving	-	-	-	50.00	1.00
Employers' Employee Costs					
15% of wages	-	-	-	40.80	0.82
Workmens' Compensation	-	-	-	15.23	0.30
System Totals	208600.00	50		1261.03	25.22

capital cost would rise to $339,000 for operator ownership of all the necessary transportation equipment, however average unit transportation cost would remain virtually the same at $10.80/tonne, since at 50 tonne/day there is unit cost difference between the contract and ownership options as discussed in Section 3.6. The system unit production cost of $25.22/tonne is lower than the market price of chips for fibre suggesting a marginally viable system in this case. Table 4.3 presents the results for the same configuration of system as shown in Table 4.2 but with a daily production of 60 tonne/day. Since at 50 tonne/day, the system has spare capacity in all component functions, higher production is possible without changing the system configuration, provided the largest capacity chip vans are used. The utilisation results in Table 4.2 indicate that the capacity of all component functions would be more effectively used but not exceeded. Total daily system operating cost rises somewhat but is offset by the increased production as unit production cost improves to $21.80/tonne. Assuming 200 operating days/annum, 60 tonnes/day, and a $27.00/tonne selling price, the net profit margin would be $62,400.00 per annum which might be sufficient economic justification for some system owner/operators to harvest whole-tree chips for fiber with this configuration.

Harvest of fuel chips with this system would be uneconomical at current market prices.

Table 4.4 describes the optimum 50 tonne/day feller-buncher and grapple skidder type harvesting system that was determined in the study. Considering Table 4.4, the capital cost of this system is $117,000 higher than the equivalent cable skidder based system. Also, total system operating cost is higher resulting in a higher system unit production cost of $28.47/tonne at 50 tonne/day. The higher unit cost can be attributed to the ineffective use of the feller-buncher and grapple skidder capacities as indicated by the utilisations of only 45% and 39% respectively.

Rework of Table 4.4 for 60 tonne/day production results in an improvement in system economic performance - the estimated total system operating cost rises to $1471/day for a unit production cost of $24.52/tonne. This is comparable to the performance of the 60 tonne/day cable skidder system and thus represents some potential for profitable operation in harvesting chips for fiber. However, the feller-buncher and grapple skidder would be better

Table 4.3
Capital and Unit Production Costs For a
Nominal 60 Tonne/Day Biomass Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost ($/Day)	Unit Cost ($/Tonne)
Felling - Manual with Chainsaw					
1 Cutters' Chainsaw - Echo Model 650	550.00	60	40	13.00	0.22
1 Chainsaw at Chipper - Echo 650	550.00	-	-	8.00	0.13
1 Cutters' Wages		60	40	64.00	1.07
1 Cable Skidder - Clark 664-D	70500.00	60	80	264.00	4.40
Chipping					
Small Chipper with Grapple Loader Morbark Super Beaver	82000.00	60	85	278.00	4.63
Transportation					
1 Mack Truck - Model RD-668F	87000.00			386.00	
2 Chip Vans - Valpri or Manac	86000.00			154.00	
Subtotal - Transportation		60	68	540.00	9.00
Miscellaneous					
Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	0.67
Landing & Road Construction/Moving	-	-	-	50.00	0.83
Employers' Employee Costs					
15% of wages	-	-	-	40.80	0.68
Workmens' Compensation	-	-	-	15.23	0.25
System Totals	338600.00	60		1313.03	21.88

Table 4.4
Capital and Unit Production Costs For a
Nominal 50 Tonne/Day Feller-Buncher Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost to Operate ($/Day)	Unit Cost ($/Tonne)
1 Chainsaw at Chipper - Echo 650	550.00	50	-	8.00	0.16
1 Feller-Buncher Caterpillar 931 C/W Fleco 38 cm. (15") shear	88000.00	50	45	228.00	4.56
1 Grapple Skidder - Clark 665-D	99000.00	50	39	240.00	4.80
Chipping					
Small Chipper with Grapple Loader Morbark Super Beaver	82000.00	50	71	261.00	5.22
Transportation					
1 Mack Truck - Model RD-668F	87000.00			386.00	
2 Chip Vans - Valpri or Manac	86000.00			154.00	
Subtotal - Transportation		50	68	540.00	10.80
Miscellaneous					
Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	0.80
Landing & Road Construction/Moving	-	-	-	30.00	1.00
Employers' Employee Costs					
15% of wages	-	-	-	40.80	0.82
Workmens' Compensation	-	-	-	15.23	0.31
System Totals	454550.00	50		1423.03	28.47

placed in a system of higher daily production as utilisation still remains low for the feller -buncher (54%) and grapple skidder (47%) at 60 tonne/day production. In practice, for a nominal 50 to 60 tonne/day system, most prospective operators would probably favour the cable skidder system because of the lower capital cost, the fact that one less machine would have to moved and maintained, and the greater range of slope and terrain conditions that could be operated.

4.3 Nominal 100 tonne/day harvesting systems

Table 4.5 describes the optimum cable skidder based harvesting system that was determined by the study for nominal 100 tonne/day production. This system is comprised of one man felling with chainsaw, two medium power cable skidders, one medium sized chipper, and a combination of contract trucking and system operator owned transport equipment totaling 2 truck tractors and 4 chip vans. The capital cost for this minimum configuration 100 tonne/day system is $546,000. The total estimated cost of operation is about $2348/day which at 100 tonne/day production yields a system unit production cost of about $23.50 per tonne, delivered to the mill, indicating reasonable potential for profitable operation. The high and similar values of utilisation for the various components indicates an efficient and well balanced system configuration.

There are a number of likely different arrangements of this basic configuration which would affect the system economics.

One would be where the system operator owned all the transportation equipment. The capital cost would then increase by $130,000 to $676,000 However, this has a negligible effect on the systems' unit production cost.

Another alternative arrangement would be production at 120 tonne/day without increasing the number of deliveries to market by using the maximum capacity chip vans available. At this production level, the utilisation of system component capacity would be higher at 80 % for felling, and 80% for skidding. The determined capacity of the Trelan DL-18 chipper would be exceeded at 120 tonne/day, but possible ways around this bottleneck would be to increase the chipper shift length by about an hour, or to use an alternate chipper of somewhat larger capacity such as the Morbark Model 20.

Table 4.5
Capital and Unit Production Costs For a
Nominal 100 Tonne/Day Biomass Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost ($/Dav)	Unit Cost ($/Tonne)
Felling - Manual with Chainsaw					
1 Cutters' Chainsaw - Echo Model 650	550.00	100	67	22.00	0.22
1 Chainsaw at Chipper - Echo 650	550.00	-	-	13.00	0.13
1 Cutters' Wages		100	67	64.00	0.64
2 Cable Skidders - Clark 664-D	141000.00	100	73	488.00	4.88
1 Chipper with Grapple Loader Trelan Model DL-18	176000.00	100	90	501.00	5.01
Transportation					
Contract of 1 Truck + 1 Chip Van	-			450.00	
1 Truck + 3 Vans - Operator Owned	216000.00			599.00	
Subtotal - Transportation		100	82	1049.00	10.49
Miscellaneous					
Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	0.40
Landing & Road Construction/Moving	-	-	-	100.00	1.00
Employers' Employee Costs					
15% of wages	-	-	-	50.40	0.50
Workmens' Compensation	-	-	-	20.30	0.20
System Totals	546100.00	100		2347.70	23.47

Rework of Table 4.5 for these alternatives results in estimated system unit production costs of about $20/tonne and $21/tonne respectively. The impact of using the Morbark Model 20 chipper instead of the Trelan model DL-18 is to increase the system capital cost by $45,000 to $591,000 for the case of some contract trucking, and to $721,000 for the case of system operator ownership of all transportation equipment. Either of these arrangements would result in significant improvement in economic performance relative to production at 100 tonne/day and indicate good potential for profitable operation at current market prices for fiber chips. The net profit margin for this system at 120 tonne/day production would be about $156,000/year, assuming 200 operating days/year at 120 tonnes/day (24,000 tonnes/year). However, harvesting of chips for fuel with this system, would not be feasible at market prices between $14 to $16/tonne. Table 4.6 describes the optimum feller-buncher and grapple skidder harvesting system that was determined by the study for nominal 100 tonne/day production.

Considering Table 4.6, system unit production cost at about $23/tonne is similar to a comparable cable skidder system at the same 100 tonne/day production and indicates good potential for profitable operation in harvesting whole tree chips for fibre. The capacity of component machines is well utilised and in reasonable balance, with the exception of the Clark 665-D grapple skidder, which has unused capacity at 100 tonne/day production. Use of either of the two smaller capacity grapple skidders described in Section 3.4 would raise utilisation to about 78% and 71% for grapple skidding, while only insignificantly raising system capital and unit production costs. The system capital cost at $591,000 for a minimum transportation arrangement is $45,000 higher than the comparable cable skidder system. For the case of operator ownership of all transportation equipment, the capital cost is about $721,000.

To operate the feller-buncher based system at 120 tonne/day production, a larger capacity feller-buncher is required, and the chipper will have to work a long shift or a larger capacity chipper would have to be used in the system. Table 4.7 shows Table 4.6 reworked for 120 tonne/day production and for a slightly altered system configuration. Considering these results, and comparing them with the results of Table 4.6, system capital cost has increased by $98,000, and system total estimated cost of operation has

Table 4.6
Capital and Unit Production Costs For a
Nominal 100 Tonne/Day Feller-Buncher Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost to Operate ($/Day)	Unit Cost ($/Tonne)
1 Chainsaw at Chipper - Echo 650	550.00	-	-	13.00	0.13
1 Feller-Buncher Caterpillar 931 C/W Fleco 38 cm. (15") shear	88000.00	100	89	271.00	2.71
1 Grapple Skidder - Clark 665-D	99000.00	100	54	288.00	2.88
Chipping Chipper with Grapple Loader Trelan Model DL-18	176000.00	100	90	501.00	5.01
Transportation Contract 1 Truck + 1 Van Own 1 Truck + 3 Vans Subtotal - Transportation	- 216000.00	100	82	450.00 599.00 1049.00	10.49
Miscellaneous Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	0.40
Landing & Road Construction/Moving	-	-	-	100.00	1.00
Employers' Employee Costs 15% of wages Workmens' Compensation	- -	- -	- -	40.80 15.23	0.41 0.15
System Totals	591550.00	100		2318.03	23.18

Table 4.7
Capital and Unit Production Costs For a
Nominal 120 Tonne/Day Feller-Buncher Harvesting System

Machine, System Function, And Quantity	Capital Cost (New 1985)	Daily Production (Tonnes/Day)	Utilisation in System (%)	Estimated Total Daily Cost to Operate ($/Day)	Unit Cost ($/Tonne)
1 Chainsaw at Chipper - Echo 650	550.00	-	-	15.60	0.13
1 Feller-Buncher John Deere 555-A C/W Fleco 38 cm. (15") shear	141000.00	120	85	374.00	3.12
1 Grapple Skidder - Clark 665-D	99000.00	120	65	307.00	2.56
Chipping					
Chipper with Grapple Loader Morbark Model 20	221000.00	120	98	611.00	5.09
Transportation					
Contract 1 Truck + 1 Van	-			450.00	
Own 1 Truck + 3 Vans	216000.00			599.00	
Subtotal - Transportation		120	82	1049.00	8.74
Miscellaneous					
Maintenance Truck and Trailer (used)	12000.00	-	-	40.00	0.33
Landing & Road Construction/Moving	-	-	-	100.00	0.83
Employers' Employee Costs					
15% of wages	-	-	-	40.80	0.34
Workmens' Compensation	-	-	-	20.30	0.17
System Totals	689550.00	120		2557.70	21.31

increased to $2558/day. The additional production offsets the increase in operating cost, however, thus yielding a lower unit production cost of $21.30/tonne. This is a worthwhile economic improvement over the $23/tonne corresponding to operation of a similar feller-buncher system at 100 tonne/day production.

Assuming a selling price of $27/tonne, the net profit margin indicated by these results for the feller-buncher system at 100 tonne/day production is estimated at about $80,000/year, assuming 200 operating days/year at 100 tonnes/day or 20,000 tonnes/year production. The net profit margin for a similar system at 120 tonne/day production, as described in Table 4.7, is similarly estimated at about $132,000/year. However, harvesting of chips for fuel with this system, would not be feasible at market prices between $14 to $16/tonne.

5 Financial Evaluation

Discounted cash flow analysis (DCF) is the recommended financial assessment procedure for evaluating the investment merits of alternative whole-tree chip harvesting system operations.[4]. A discounted cash flow analysis was performed for each of the optimum small scale harvesting system alternatives described in section 4 in order to have an objective basis for harvesting system comparison, selection, and recommendation.

The required revenue, capital cost, and operating cost data needed for each DCF analysis was based on the economic results presented in the preceding sections, or on the data from which these results were determined. One adjustment was necessary to these earlier results, however, in order to perform the DCF analysis procedure properly. Total system operating costs as presented in section 4 had to be adjusted downward for each component machine, and therefore for each system, in order to accurately reflect operating costs as intended for use in DCF analysis. Essentially, this meant removing the component of cost included in the machine rate costing program "MACHINE" that added a 15% before tax return on capital investment in establishing the daily rate for each machine. In DCF analysis, the discount rate accounts for return on capital investment. The differences between net profit in the foregoing sections and as presented hereinafter are attributable to this adjustment. Table 5.1 presents the estimated annual net profit results for each harvesting system of section 4 for typical market price ranges of $25 and $27/green tonne (hardwood whole-tree hardwood chips for fiber), and $14 and $16/green tonne (whole-tree chips for fuel). As indicated in the table, all systems except system 1 were determined to be profitable when producing whole-tree hardwood chips for fiber. For fuel chip harvesting, significant losses are projected for all systems.

The profit figures of Table 5.1 exclude consideration of the financial implications of the capital requirements for equipment and the time value of, and required return on investment, for this capital expenditure. These factors are accounted for in discounted cash flow analysis.

Table 5.1
Estimated Annual Net Profit (Loss)
For Nominal 25, 50, and 100 tonne/day Whole-tree Chip Harvesting Systems
($ '000)

System Designation	Production Rate	System Capital Cost	Estimated Annual Operating Cost	Estimated Annual Net Profit ($ '000)			
				Selling Price ($/green tonne)			
	(tonne/day)	($ '000)	($ '000)	$27	$25	$16	$14
System 1 - (See Table 4.1)	25	191	154	(18)	(29)	(74)	(84)
System 1 - (See Table 4.1)	30	191	156	6	(6)	(60)	(72)
System 2 - (See Table 4.2)	50	209	226	44	24	(66)	(86)
System 3 - (See Table 4.3)	60	339	259	65	41	(67)	(91)
System 4 - (See Table 4.4)	60	451	247	77	53	(55)	(79)
System 5 - (See Table 4.5)	100	546	419	121	81	(99)	(139)
System 5 - (See Table 4.5)	120	592	426	222	174	(42)	(90)
System 6 - (See Table 4.6)	100	592	407	133	93	(87)	(127)
System 7 - (See Table 4.7)	120	690	449	199	151	(65)	(113)

Table 5.2
Results of Before-Tax Discounted Cash Flow Analysis Of
Nominal 25, 50, and 100 tonne/day Whole-tree Chip Harvesting Systems
($ '000)

System Designation	Production Rate	System Capital Cost	Estimated Annual Operating Cost	Net Present Value [1] ($ '000) For Selling Price ($/green tonne)			
	(tonne/day)	($ '000)	($ '000)	$27	$25	$16	$14
System 1 - (See Table 4.1)	25	191	154	(270)	(318)	(516)	(560)
System 1 - (See Table 4.1)	30	191	156	(165)	(217)	(454)	(507)
System 2 - (See Table 4.2)	50	209	226	(16)	(104)	(499)	(586)
System 3 - (See Table 4.3)	60	339	259	(54)	(159)	(633)	(738)
System 4 - (See Table 4.4)	60	451	247	(113)	(218)	(692)	(798)
System 5 - (See Table 4.5)	100	546	419	(15)	(191)	(980)	(1,156)
System 5 - (See Table 4.5)	120	592	426	382	171	(776)	(987)
System 6 - (See Table 4.6)	100	592	407	(9)	(184)	(974)	(1,149)
System 7 - (See Table 4.7)	120	690	449	183	(28)	(975)	(1,186)

[1] For years 1 to 5, 7 percent discount rate, and system capital cost expenditure at start of year 1.

Table 5.2 presents the results of the discounted cash flow analyses corresponding to each of the systems and selling prices shown in Table 5.1. The results indicate negative cash flow for the first five years of operation for all systems, including harvesting of chips for fiber, with the exception of 2 cases - the nominal 100 tonne/day systems 5 and 7 when producing at 120 tonne/day. Thus, systems 5 or 7 are the preferred configurations for operation. Of these two systems, system 5 is preferable from the financial investment viewpoint, since it would return more than twice the positive cash flow over 5 years at a 7% discount rate.

An important point indicated by Table 5.2 is the sensitivity of system financial performance to selling price as illustrated, for example, by the NPV figures for system 7. A $2.00 lower selling price ($27 to $25/tonne) changes a postive cash flow of $183,000 to a $28,000 negative cash flow. It is also worth noting that financial performance is also sensitive to daily production rate as illustrated by comparison of the results for system 5 in Table 5.2 at daily productions of 100 and 120 tonne/day.

Recalculation of Table 5.2 for a 15% discount rate results in no significant changes in the relative ranking of the systems financial performance. Furthermore, net present values remained negative if they were negative at a 7% discount rate, and generally increased in magnitude in the negative direction. The revised net present values for systems 5 and 7 at a selling price of $27/tonne and a 15% discount rate would be $264,000 and $77,000 respectively, indicating a reduced yet still viable financial basis for operating these two systems.

6 Conclusions and Recommendations

It is clear from the results of the foregoing analyses that harvesting whole-tree chips for fuel is not cost effective with optimum harvesting system configurations producing at approximately 25, 50 and 100 tonnes/day. The market price for fuel wood chips at the industrial scale is determined by its competitive value relative to alternate industrial fuels such as No. 6 fuel oil. This price - $14 to $16 per green tonne - is not high enough to allow profitable operation of a small scale fuel chip harvesting system as an independent business. Further, the magnitude of both the projected losses, and the negative net present value of investments as determined for fuel harvesting systems, indicate that it is unlikely that the capital cost, operating cost, productivity relationship of machines or systems at this scale could be altered enough by machine improvements to result in profitable operation. The operation of larger scale systems, which achieve more efficient use of capital, manpower, and other resources on a unit production basis, are indicated as the most reasonable direction in which to move for cost effective fuel wood chip harvesting.

Recommendation 1. It is recommended to not undertake small scale harvesting system operation for fuel wood chip production using the optimum small scale whole-tree chip harvesting systems identified in the study.

For the harvest of whole-tree chips for fiber, there are several optimum small scale harvesting system alternatives which show good potential for being cost effective, profitable, and reasonable investments. The preferred alternative for the independent contractor is a nominal 100 tonne/day cable skidder type harvesting system configuration producing at 120 tonne/day as described in Table 4.5.

Recommendation 2. In considering operation of a small scale whole-tree chip harvesting system for fiber harvest, first consideration should be given to a nominal 100 tonne/day system configuration as described in Table 4.5., namely a chainsaw felling, cable skidder based system.

A nominal 100 tonne/day feller-buncher and grapple skidder type harvesting

system, as described in Table 4.7 and producing 120 tonne/day, was the only other system which yielded positive net present value in the DCF analyses. Where stand, slope, and terrain conditions allow, this system could also be considered for operation, although it would be a less attractive investment than the system of Table 4.5.

Recommendation 3. A nominal 120 tonne/day feller-buncher and grapple skidder type harvesting system (Table 4.7) should be the second investment alternative considered by the prospective small scale system operator for harvesting whole-tree chips for fiber.

All other optimum small scale systems returned negative NPV's in the DCF analyses (Table 5.2). Therefore, in general, systems at these levels should not be considered for operation with perhaps one exception. System 2 (Table 4.2) and system 3 (Table 4.3) are basically the same cable skidder type system but they produce at different rates of 50 tonnes/day and 60 tonne/day respectively, and have different capital costs because of different transportation equipment ownership alternatives. The DCF analyses for these two system alternatives produced small enough negative NPV's (Table 5.2) that they should be considered within the margin of error of the cost analysis procedures, since the financial analysis results are sensitive to both selling price, and therefore also to the estimated total system unit production cost estimates. For example, rework of the DCF analysis for system 3 of Table 5.2 for a capital cost of $209,000 instead of $339,000, which represents the difference between complete ownership and contract of trucking, results in a positive NPV of $76,000 versus a negative $54,000for system 3. Therefore, systems 2 and 3 could be considered for operation in cases where either favourable circumstances exist, or can be controlled by a capable system operator.

Recommendation 4. System 2 (Table 4.2) and system 3 (Table 4.3) should be considered for harvesting of fiber chips at nominal 50-60 tonne/day production rates in circumstances favouring economical operation.

System 4 (Table 4.4), the nomimal 50 tonne/day feller-buncher and grapple skidder type harvesting system, is under-utilised and too capital intensive to be considered for operation. Similarly, optimum configurations of nominal 25 tonne/day harvesting systems are not cost effective for

harvesting of whole-tree chips for fiber.

Recommendation 5. Optimum configurations of feller-buncher based whole-tree chip harvesting systems producing fiber chips at a nominal 50 tonne/day, and all optimum configurations of nominal 25 tonne/day systems, as identified in the study, should not be considered for operation.

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Appendix A

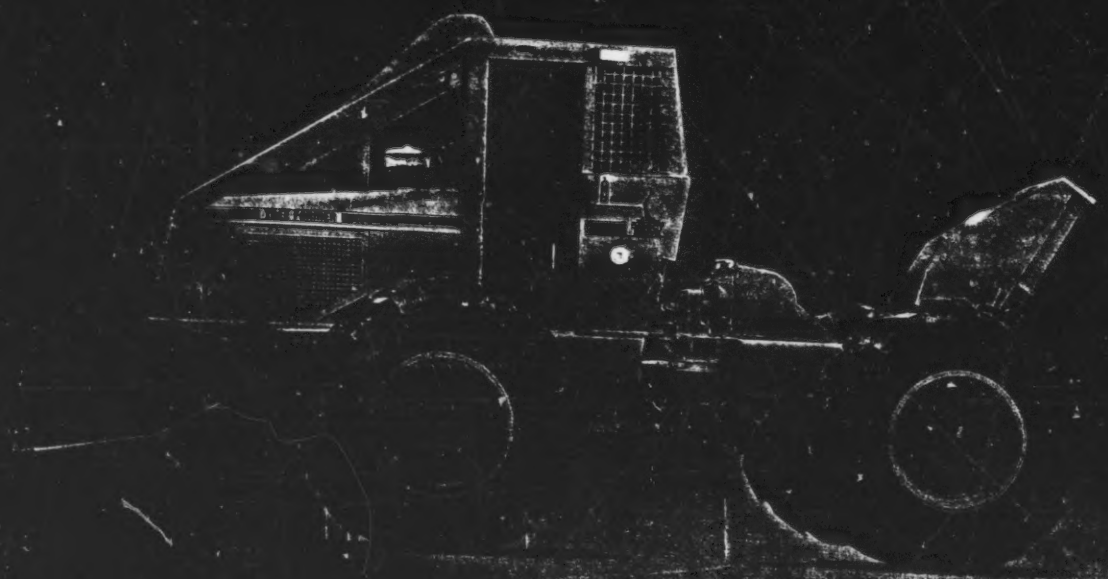
Cable Skidder Specifications

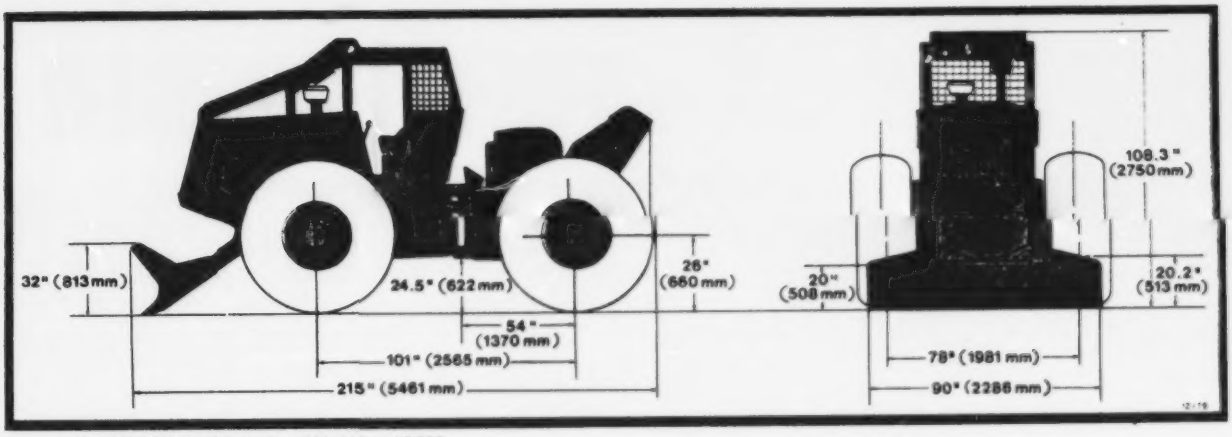
TREE FARMER

C4D

DIRECT DRIVE
80 HP CLASS

- 4-speed synchromesh transmission
- Constant mesh, 2-speed, full reversing transfer case
- "No Spin" differentials and outboard planetary gearing on front and rear axles
- Controlled flow hydraulic steering — adjusts for any speed
- Large diameter tapered hinge pins
- Central lubrication system
- Economical Deutz air-cooled engine
- Rugged, rectangular tube ROPS canopy





AS MEASURED ON 16.9" X 30" (429 X 762 mm) TIRES

TREE FARMER C4D DIRECT DRIVE 80 HP CLASS

SPECIFICATIONS

ENGINE (Diesel) — Deutz F4L 912

Rated horsepower	80
Net flywheel horsepower	72
Full load governed RPM	2650
Number of cylinders	4
Bore	(100mm) 3.937"
Stroke	(120mm) 4.72"
Displacement	(3.77 litres) 230.1 cu. in.
Fuel	No. 2 fuel oil
Fan	Suction

INSTRUMENTS AND GAUGES

Ammeter, hourmeter, oil pressure, engine temperature gauges, air cleaner restriction indicator, brake warning light, master disconnect switch and 12 volt electrical system.

CLUTCH

Mechanically actuated.
Heavy duty spring loaded (305mm) 12" diameter plate.

TRANSMISSION

4 speed synchromesh (all gears).
Gear ratios: 1st 6.32:1 2nd 3.09:1 3rd 1.68:1 4th 1.01:1

TRANSFER CASE

Constant mesh two speed full reversing.
Ratios: High 1.01:1 Low 1.48:1

AXLES (PRS 204 Planetary or equivalent)

Four wheel drive. Front and rear "No-Spin" differential.

Axle ratio	25.74:1
Front axle oscillation ground to tire	(482mm) 19"

BRAKES

Service: Foot operated – internal expanding. Capacity: (2710 N-m) 2000 ft. lb. hot. Mechanical parking brake.

TIRES (standard)

(429 X 760mm) 16.9" X 30"

SPEEDS (429 x 760 mm / 16.9" x 30" tires)

Gears	1st		2nd		3rd		4th	
	mph	kmh	mph	kmh	mph	kmh	mph	kmh
Low	1.59	2.56	3.03	4.88	5.83	9.38	10.0	16.09
High	2.33	3.75	4.76	7.66	8.70	14.0	14.7	23.65

CAPACITIES

Hydraulic tank	(50 litres) 11 Imp. gal., 13.2 US gal.
Fuel system	(90.8 litres) 20 Imp. gal., 24 US gal.

HYDRAULICS

Direct drive pump	(106 L) 23 Imp/28 US gal/min at 2650 RPM
Steering cylinder (No-Shock)	(89 X 515mm) 3.5" X 20.25"
Dozer cylinders	(89 X 356mm) 3.5" X 14"
Working pressure	(12,070 kPa) 1750 PSI

STEERING

Hydraulic powered, articulated frame steering.
Turning radius outside tire ..... (4.7m) 15' 6"

WINCH

Gearmatic 9 winch mounted on rear frame.

Winch drum diameter	(152.4mm) 6"
Winch drum length	(197mm) 7.75"
Winch drum flange depth	(279.4mm) 11"
Cable capacity	(41.5m of 14mm dia.) 136' of 9/16" cable

LOGGING ARCH

Optional locations. Fabricated construction with two vertical and a large horizontal fairlead roller mounted on sealed anti-friction bearings.

WEIGHT

Front	3,988 kg	8,792 lbs.	70%
Rear	1,709 kg	3,768 lbs.	30%
Total	5,697 kg	12,560 lbs.	100%

STANDARD EQUIPMENT

Deluxe seat, removable wire mesh engine side panels, removable canopy, dozer blade (2286 X 508mm) 90" X 20", hand throttle, dry type air cleaner, muffler/spark arrestor, full flow hydraulic oil filter, central lubrication, tool box under seat, 12 volt batteries (2), alternator, cigar lighter, fire extinguisher, seat belts, and operators and parts manuals.

OPTIONAL EQUIPMENT

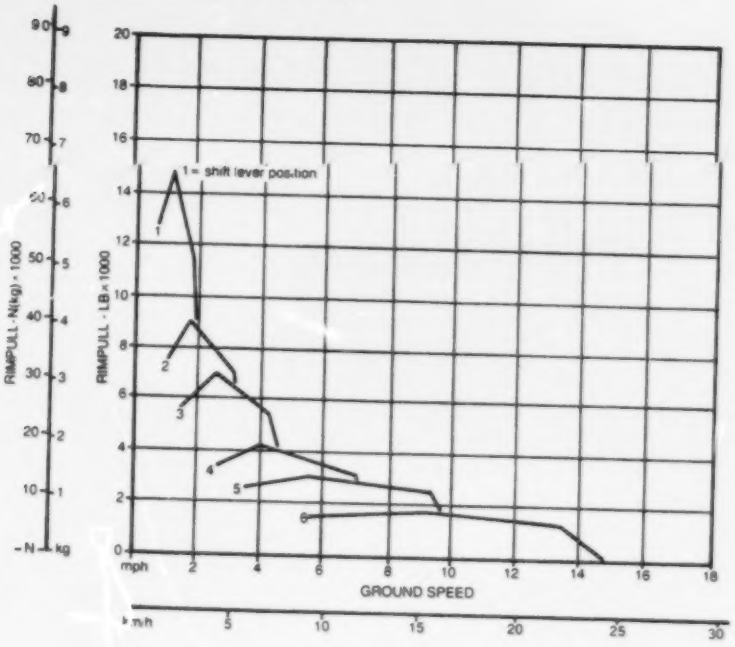
Optional tire sizes, Can Car 20 winch, 24 volt starting, 5 speed transmission, dual disc brakes, top fairlead roller, fenders, wheel steering, rubber mounted lights, enclosed cab with wipers, heater, and defroster, and dual steering.

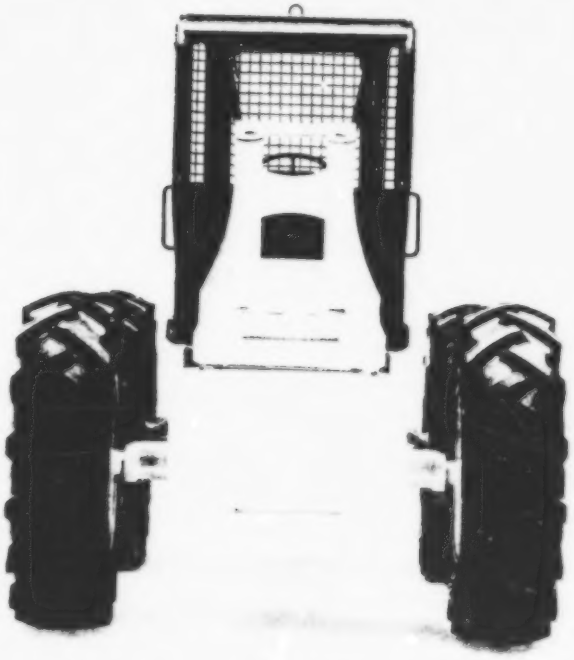
Tree Farmer reserves the right to change specifications without incurring any obligations

Hawker Siddeley Canada INC.
FORESTRY EQUIPMENT DIVISION
P.O. BOX 1004, MALTON POSTAL STN., MISSISSAUGA, ONTARIO L4T 3Y1

PRINTED IN CANADA JUNE 1980

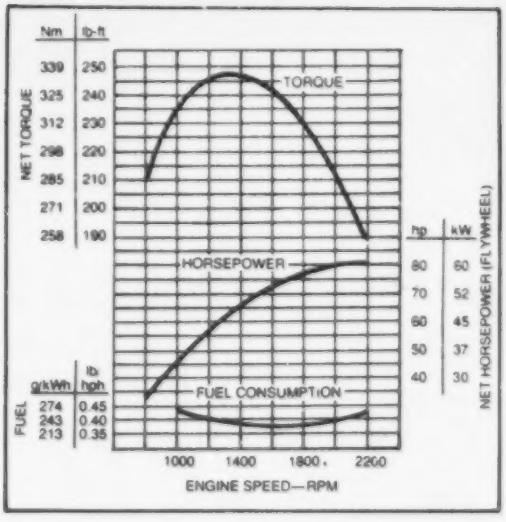
340D SKIDDER PERFORMANCE





Model shown may include options

ENGINE PERFORMANCE



FEATURES

80 SAE net hp (60 kW) John Deere turbocharged diesel

Articulated-frame power steering

Automotive-type, position-responsive steering

Oscillating front axle

3-speed Syncro-Range transmission

Front-axle differential lock

Wet-disk power brakes

Wet-disk parking brake

Hydraulically actuated winch

Arch with adjustable rollers

ADD VERSATILITY WITH:

Stacking blade

Extended log bumper

Reversible narrow/wide-gauge wheels and tires

67

440D SKIDDER SPECIFICATIONS

(Specifications and design subject to change without notice. Wherever applicable, specifications are in accordance with ICED and SAE Standards. Except where otherwise noted, these specifications are based on a unit equipped with Syncro-Range transmission, 18.4-26, 10 PR tires, full fuel tank, 175-lb (79 kg) operator and standard equipment.)

Power (@ 2200 engine rpm):	**SAE**	**DIN**
Gross	86 hp (64.1 kW)	
Net	80 hp (60 kW)	60 kW

Net engine power is with standard equipment including air cleaner, exhaust system, alternator and cooling fan. Gross power is without cooling fan. Power ratings are at standard conditions per SAE J1349 and DIN 70 020. No derating is required up to 10,000 feet (3050 m) altitude.

Engine: John Deere turbocharged 4-cylinder-diesel, 4-stroke cycle

Bore and stroke	4.19×5.00 in. (106.4×127 mm)
Piston displacement	276 cu. in. (4.524 L)
Compression ratio	16.2 to 1
Maximum torque @ 1300 rpm	247 lb-ft (335 Nm) (34.1 kg-m)
Torque rise	29 percent
NACC or AMA (U.S. Tax) horsepower	28
Lubrication	Pressure system w/full-flow filter
Cooling	Pressurized w/thermostat and fixed bypass
Fan	Blower
Air cleaner	Dry-type w/restriction indicator
Electrical system	12-volt w/42-amp alternator
Battery	Reserve capacity: 180 min.

Differential:

Front axle with hydraulic-locking differential. Solid rear axle with no differential action.

Transmission: Syncro-Range.

Constant-mesh gearing with 6 speeds forward, 3 reverse. Three forward speed ranges with synchronized shifting between low and high within each range. Clutch is 12 inches (305 mm), dry, feramic-faced, pedal-operated.

Travel Speeds (2200 engine rpm, no tire slip):

	mph	**km/h**
Forward	1.7-14.1	2.7-22.7
Reverse	1.7-8.5	2.7-13.7

Drive Axles:

Four-wheel drive with S2 Series axles. Inboard planetaries on all axles. Front axle oscillates 15 degrees above and below horizontal. Travel at tire center line 20 in. (508 mm).

Steering:

Hinged-frame power steering. Position-responsive steering actuated by dual double-acting cylinders. Steering system has hydraulic-pressure priority.

Outside clearance circle w/o blade	33 ft. 10 in. (10.3 m)
Outside clearance circle w/blade	34 ft. 10 in. (10.6 m)
Outside clearance circle w/o blade, solid rear axle	37 ft. 3 in. (11.4 m)
Outside clearance circle w/blade, solid rear axle	38 ft. 3 in. (11.7 m)
Steering wheel rotation, max. left to right	3 turns

Brakes:

Service: Hydraulic power, foot-actuated, enclosed wet-disk service brake for front and rear. Located on transmission output shaft.

Parking, winching and emergency stop: Hand-operated mechanical wet-disk brake located on driveline for braking front and rear axles. Hydraulic release.

Hydraulic System:

Closed center, constant pressure. Variable-displacement pump drive from engine crankshaft: 25 gpm (1.58 L/s), 2000 psi (13 790 kPa) (140.6 kg/cm²) @ 2200 engine rpm.

Full-flow filtration, 10-micron filter, oil-to-air cooler. Charge pump driven from winch drive.

Hydraulic Cylinders	**Bore**	**Stroke**
Blade lift cylinders (2)	3.50 in. (89 mm)	14.25 in. (362 mm)
Steering cylinders (2)	2.75 in. (70 mm)	14.37 in. (365 mm)
Blade lift rod (2) dia.	1.50 in. (38.1 mm)	
Steering cylinder rod (2) dia.	1.75 in. (44.5 mm)	

Cylinder rods are ground, heat-treated, chrome-plated, polished.

Tires:

16.9-30, 10 PR, steel, LS2, logger
18.4-26, 10 PR, steel, LS2, logger
18.4-26, 10 PR, LS2, logger
18.4-34, 10 PR, steel, LS2, logger
18.4-34, 16 PR, synthetic, LS2, logger
23.1-26, 10 PR, steel, LS2, logger
23.1-26, 16 PR, synthetic, LS2, logger
28.1-26, 10 PR, steel, LS2, logger
68/34-26, 16 PR, synthetic, LS2, logger, tubeless

Capacities:	**U.S.**	**Liters**
Fuel tank	41 gal	155.2
Cooling system	8 gal	30.3
Engine lubrication, w/filter	15 qt	14.2
Transmission and hydraulic system	8 gal	30.3
Front differential	9 gal	34.1
Rear differential	4.5 gal	17
Winch	2.5 gal	9.5

Blade: Hydraulic control

Width	6 ft. 11 in. (2.11 m)
Max. lift above ground level	4 ft. (1.22 m)
Max. drop below ground level	9.5 in. (241 mm)

Cable Arch:

Horizontal roller	6 in. (152 mm) dia.
Vertical rollers (hardened steel)	4.5 in. (114 mm) dia.
Working height settings (top of horizontal roller to ground):	
Lower	5 ft. 11 in. (1.79 m)
Upper	6 ft. 4 in. (1.94 m)

Winch:

Live mechanical drive; hydraulically actuated clutch and brake. Single lever control.

Winch capacities:*

½-in. (12.7 mm) cable	223 ft. (68 m)
⅝-in. (15.8 mm) cable	146 ft. (44.5 m)
¾-in. (19.1 mm) cable	103 ft. (31.4 m)

*Calculated—no allowance made for loose or uneven spooling.

Linepull:**

Bare drum	26,660 lb. (118.6 kN) (12 093 kg)
Full drum	18,129 lb. (80.6 kN) (8223 kg)

**Based on maximum engine torque.

Line speed (2200 rpm):

Bare drum	131 fpm (40 m/min)
Full drum	187 fpm (57 m/min)
SAE Operating Weight w/Blade	15,090 lb. (6845 kg)
SAE Operating Weight w/o Blade	14,250 lb. (6464 kg)

Additional Standard Equipment:

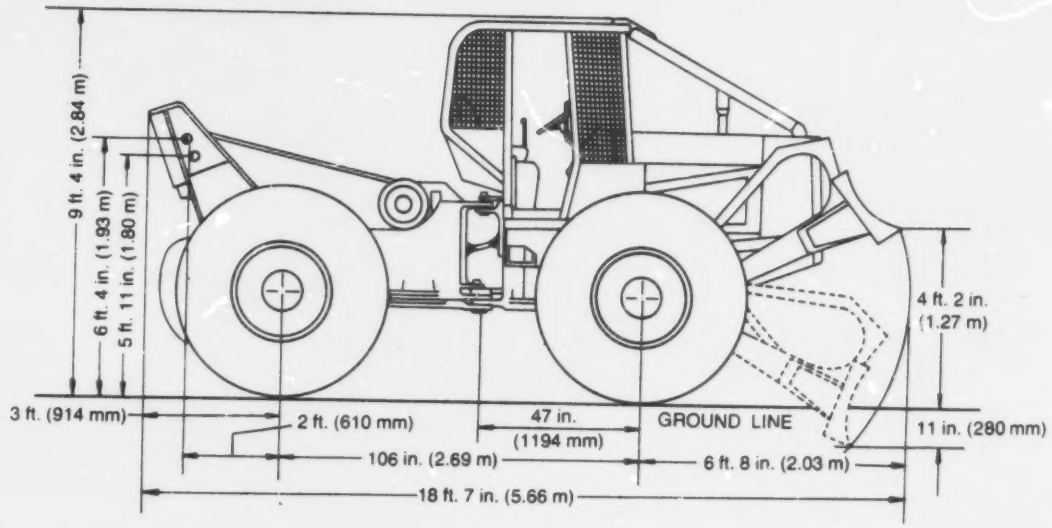
Alternator warning light
Bottom guards, full length
Cable arch w/dual-position roller
Canopy (ROPS), brush screens, limb risers
Cushion seat w/suspension position adjustment and seat belt
Engine oil pressure warning light
Engine sideshields
Exhaust w/rain deflector
Extended log bumper
Foot throttle
Full steering wheel
Gauges:
  Electric hourmeter
  Engine coolant temperature
  Fuel level
Heavy-duty starter
Hinge locking bar
Horn
Key switch w/pushbutton safety start
Muffler
Parking brake warning light
Vandal protection for radiator filler cap
Winch

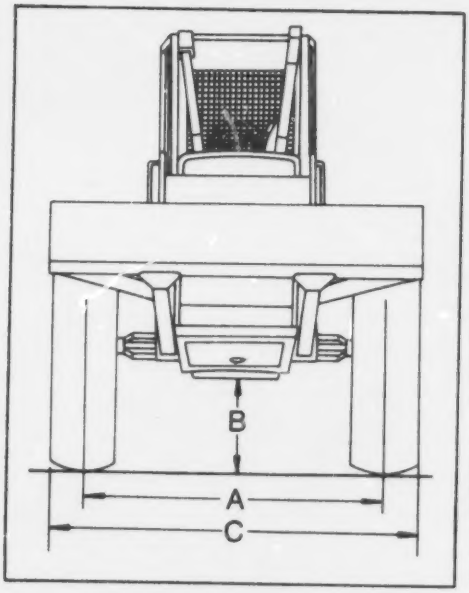
Optional or Special Equipment:

Cab (ROPS) w/noise treatment, windshield washer and wiper, limb risers
Canopy lights
Canopy (ROPS), windows, door, brush screens, limb risers
Engine coolant heater
Cold-weather starting package:
  Batteries (2), 420-min. reserve capacity
  Ether starting aid, electric
  Hand speed control
Fire extinguisher
Hand throttle
Secondary steering system (requires two AR105227 accumulators)
Stacking blade
3-in. (76 mm) seat belt
Vandal protection for instrument panel and fuel tank
Winch warm-up kit

440D SKIDDER DIMENSIONS

Sideview dimensions are for skidder equipped with 18.4-26 tires.


9 ft. 4 in. (2.84 m)
6 ft. 4 in. (1.93 m)
5 ft. 11 in. (1.80 m)
4 ft. 2 in. (1.27 m)
3 ft. (914 mm)
2 ft. (610 mm)
47 in. (1194 mm)
GROUND LINE
11 in. (280 mm)
106 in. (2.69 m)
6 ft. 8 in. (2.03 m)
18 ft. 7 in. (5.66 m)



TIRE SIZE AND WHEEL TYPE		A WHEEL TREAD	B GROUND CLEARANCE	C OVERALL WIDTH
16.9-30		76 in. (1.93 m)	19 in. (483 mm)	93 in. (2.36 m)
18.4-26 (Standard wheel and tire)		76 in. (1.93 m)	18 in. (457 mm)	94 in. (2.39 m)
18.4-26 (Narrow-gauge wheel and tire, Type B)		66 in. (1.68 m)	18 in. (457 mm)	85 in. (2.16 m)
18.4-26 (Narrow/wide-gauge wheel and tire, Type A)	Wide-gauge mounting	78 in. (1.98 m)	18 in. (457 mm)	96 in. (2.44 m)
	Reversed narrow-gauge mounting	66 in. (1.68 m)	18 in. (457 m)	85 in. (2.16 m)
18.4-34		76.5 in. (1.94 m)	22. in. (559 mm)	95 in. (2.41 m)
23.1-26		82 in. (2.08 m)	21 in. (533 mm)	106 in. (2.69 m)
28.1-26*		85 in. (2.16 m)	22 in. (559 mm)	114 in. (2.90 m)
68/34-26*		85 in. (2.16 m)	22. in. (559 mm)	117 in. (2.97 m)

*S3 Series special-application axle required.

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540B SKIDDER SPECIFICATIONS

(Specifications and design subject to change without notice. Wherever applicable, specifications are in accordance with ICED and SAE Standards. Except where otherwise noted, these specifications are based on a unit equipped with 23.1-26, 10-PR tires, full fuel tank, 175-lb. (79 kg) operator and standard equipment.)

Power (@ 2200 engine rpm):	**SAE**	**DIN**
Gross	96 hp (71.5 kW)	
Net	90 hp (67 kW)	67 kW

Net engine power is with standard equipment including air cleaner, exhaust system, alternator and cooling fan. Gross power is without cooling fan. Power ratings are at standard conditions per SAE J1349 and DIN 70 020. No derating is required up to 10,000 feet (3050 m) altitude.

Engine: John Deere turbocharged diesel, 4-cylinder, 4-stroke cycle

Bore and stroke	4.19×5 in. (106×127 mm)
Piston displacement	276 cu. in. (4.524 L)
Compression ratio	16.2 to 1
Maximum torque @ 1400 rpm	270 lb-ft (366 Nm) (37.32 kg-m)
NACC or AMA (U.S. Tax) horsepower	28
Lubrication	Pressure system w/full-flow filter
Cooling	Pressurized w/thermostat and fixed bypass
Fan	Blower
Air cleaner w/restriction indicator	Dry
Electrical system	12-volt w/alternator
Batteries (2)	Reserve capacity: 340 minutes

Differentials:

Front and rear ..... Full differentials w/hydraulic lock

Engine Clutch Disconnect:

Hand-operated, spring-loaded, dry-disk. Single plate, 12 in. (305 mm).

Transmission:

Power Shift with planetary gears, hydraulically actuated wet-disk clutches and brakes; provides 8 speeds forward—4 reverse. Controlled by single lever on console.

Travel Speeds (2200 engine rpm, no tire slip):

Forward: 1.7 to 17.9 mph (2.7 to 28.8 km/h)
Reverse: 2.0 to 5.8 mph (3.2 to 9.3 km/h)

Drive Axles:

Four-wheel drive with inboard planetary gears on all axles. Front axle oscillates 15 degrees above and below horizontal. 20 in. (508 mm) total travel at tire center line.

Brakes:

Hydraulic power actuated, dual controlled disks on 4 wheels, lockable for winching. Hand-operated mechanical brake for parking and emergency stop.

Power Steering:

Articulated frame hydraulically actuated by dual cylinders. Steering system has hydraulic pressure priority.

Turning radius	16 ft. 4 in. (4.98 m)
Turning clearance	34 ft. 5 in. (10.49 m)

Hydraulic System:

Closed-center constant pressure. Variable-displacement pump driven from crankshaft ..... 25 gpm (1.58 L/s) 2000 psi (13 790 kPa) (140.6 kg/cm²) @ 2200 engine rpm. Full flow filtration. Oil-to-air cooler.

Tires:

18.4-26, 10-PR, steel-ply, LS2
18.4-34, 10-PR, steel-ply, LS2
18.4-34, 16-PR, Kevlar, LS2
23.1-26, 10-PR, steel-ply, LS2
23.1-26, 16-PR, Kevlar, LS2
28.1-26, 10-PR, steel-ply, LS3
68/34-26, 16-PR, Kevlar tubeless, LS2

Capacities:	**U.S.**	**Liters**
Fuel tank	42 gal.	159
Cooling system	8 gal.	30.3
Engine lubrication, including filter	15 qt.	14.2
Transmission and hydraulic system	9 gal.	34.1
Front differential	4.5 gal.	17
Rear differential	4.5 gal.	17
Winch	2.5 gal.	9.5

Additional Standard Equipment:

Alternator warning light
Bottom guards
Canopy w/ROPS, brush screens and limb risers
Cigaret lighter
Cushion seat w/suspension, position adjustment and seat belt
Engine side shields
Ether starting aid
Exhaust w/rain deflector
Fire extinguisher
Gauges:
- Electric hourmeter
- Engine coolant temperature
- Engine oil pressure
- Fuel
- Transmission oil temperature

Hand and foot throttle
Heavy-duty starter
Hinge locking bar
Horn
Integral log bumper
Key switch w/pushbutton safety start
Log arch w/multiposition roller
Muffler
Parking brake w/warning light and buzzer
Stacking blade
Transmission oil pressure warning light
Solid-state voltage regulator
Vandal protection
Winch

SAE Operating Weight ..... 16,675 lb. (7564 kg)

Winch:

Cable capacities*:

½-in. (12.7 mm) cable	223 ft. (68 m)
⅝-in. (15.8 mm) cable	146 ft. (45 m)
¾-in. (19.1 mm) cable	103 ft. (31.4 m)

*Calculated: No allowance made for loose or uneven spooling.

Linepull**:

Bare drum	30,599 lb. (136.1 kN) (13 879 kg)
Full drum	20,807 lb. (93 kN) (9438 kg)

**Based on maximum engine torque.

Line speed (2200 rpm):

Bare drum	125 fpm (38.1 m/min)
Full drum	179 fpm (55 m/min)

Blade: Hydraulic control

Width	6 ft. 11 in. (2.11 m)
Height (ends)	1 ft. 8 in. (508 mm)
Height (center)	2 ft. 3 in. (686 mm)
Max. lift above ground level	4 ft. 4 in. (1.31 m)
Max. drop below ground level	9 in. (229 mm)

Arch:

Horizontal roller	6 in. (152 mm) dia.
Vertical rollers (through-hardened steel)	4.5 in. (114 mm) dia.
Working height (top of horizontal roller to ground):	
Settings: Lower	6 ft. (1.83 m)
Upper	6 ft. 5 in. (1.95 m)

Special Equipment:

3-in. (76 mm) seat belt
Cab w/ROPS, heater, noise treatment and wiper
Canopy w/ROPS, screened doors, right window, windshield and wiper
Lights (field only)
Engine coolant heater
Emergency steering system
Wheel weights

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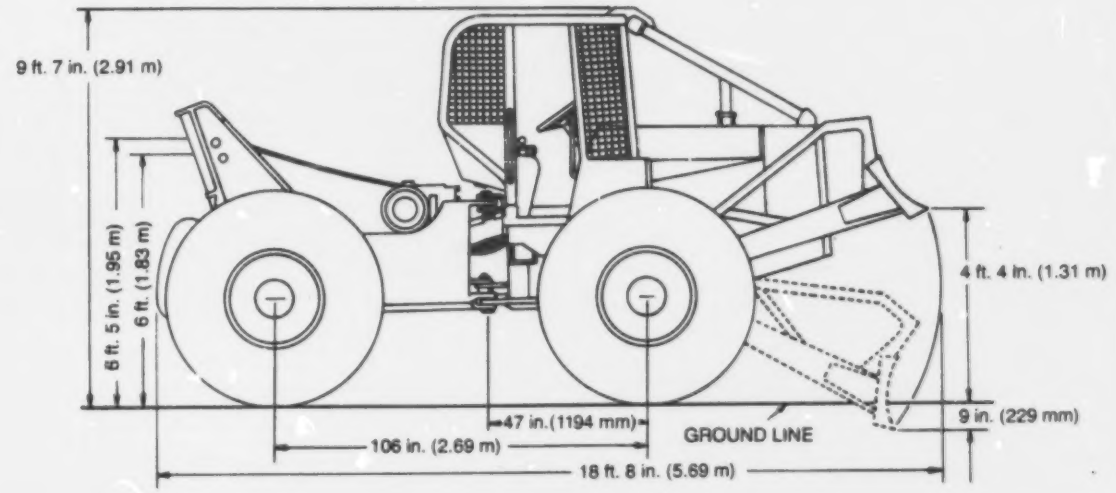
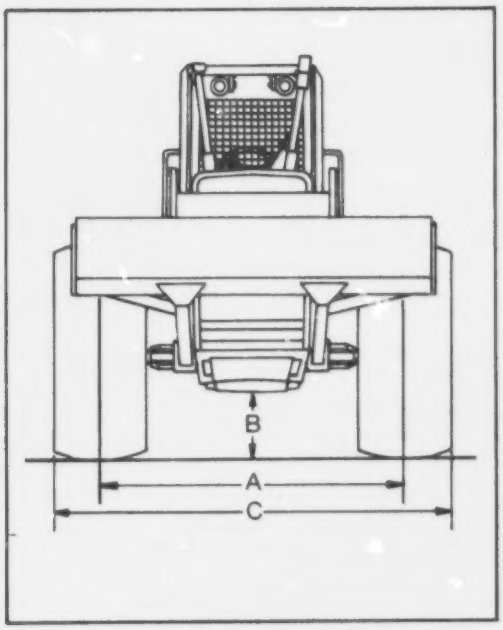
540B SKIDDER DIMENSIONS

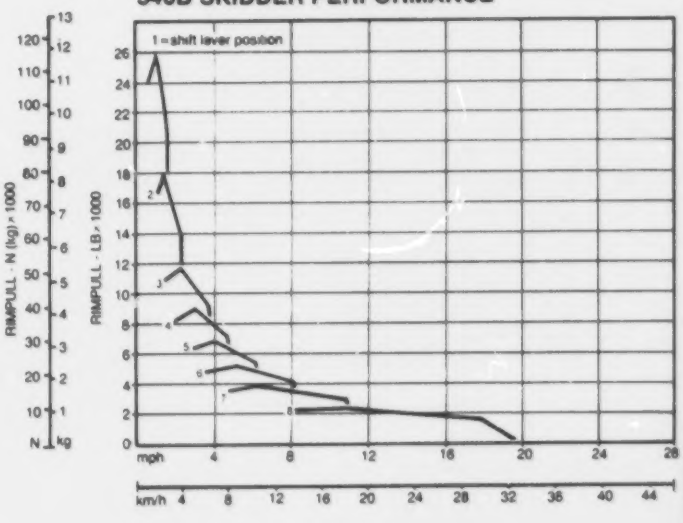
Sideview dimensions are for skiddor equipped with 23.1-26 tires, adjustable arch, and regular bumper in upper position.





TIRE SIZE	A WHEEL TREAD	B GROUND CLEARANCE	C OVERALL WIDTH
18.4-26	76 in. (1.93 m)	1 ft. 8.5 in. (521 mm)	7 ft. 10.4 in. (2.40 m)
18.4-34	76.5 in. (1.94 m)	1 ft. 10 in. (559 mm)	7 ft. 11.1 in. (2.42 m)
23.1-26	82.0 in. (2.08 m)	1 ft. 9 in. (533 mm)	8 ft. 9.8 in. (2.69 m)
28.1-26	85.4 in. (2.17 m)	1 ft. 9.5 in. (546 mm)	9 ft. 5.5 in. (2.88 m)
68 34-26	85.4 in. (2.17 m)	1 ft. 10.3 in. (566 mm)	9 ft. 9 in. (2.97 m)

540B SKIDDER PERFORMANCE



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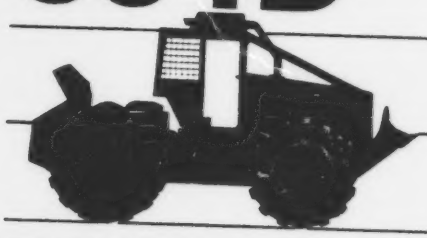
CLARK 664D

Cable Skidder Specifications



CUMMINS POWERED

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ENGINE

Make	Cummins
Model	4BT-3.9
Maximum hp (kW)*	100 (74,5)
Flywheel hp (kW)**	90 (67,1)
Governed rpm	2500
Maximum torque, lbf•ft	250 @ 1500
N•m	339 @ 1500
Bore and stroke, in	4.02×4.72
mm	102,1×119,8
Number of cylinders	4
Displacement, in³ (L)	239,3 (3,9)
Fuel tank capacity, U.S. gal (L)	45 (170,3)
Electrical system (alternator)	12V (61A)

*Maximum hp of basic engine; standard ambient conditions per SAE J816.

**Net usable hp at engine flywheel at 500 ft (152,4 m) altitude & 85°F (29.5°C) ambient conditions with fan, alternator, water pump, lube oil pump, fuel pump, and air cleaner.

DRIVETRAIN

TORQUE CONVERTER: Clark industrial type; 2.85 to 1 multiplication factor.

TRANSMISSION: Clark countershaft type powershift, three speeds forward, three speeds reverse. Travel speeds:*

mph	3.6	6.9	15.5
km/h	5,8	11,1	25,0

*Measured with 18.4-34, 16PR tires.

AXLES: Clark with low-friction roller bearing planetary in each wheel. Single-piece cast steel housing with bolt-on spindles; front and rear NoSpin differentials. Front axle oscillates a total of 28°, rear axle fixed.

BRAKES

SERVICE: Clark hydraulically actuated, multiple disc, oil cooled; fully enclosed on rear of transmission.

PARKING: Manually actuated lock on service brake.

TIRES

Standard	18.4-34 16PR
Optional	18.4-26 10PR, 18.4-34 10PR, 23.1-26 10PR, 23.1-26 16PR, 28.1-26 10PR, 28.1-26 16PR, 24.5-32 12PR, 24.5-32 16PR

HYDRAULIC SYSTEM

PUMP: Gear type; flywheel driven by splined shaft through torque converter.

Pump capacity @ 2000 rpm 23.8 U.S. gpm (90,1 L/min)

System capacity ..... 15.6 U.S. gal (59,0 L)

Reservoir capacity ..... 14.75 U.S. gal (55,8 L)

CYLINDERS: Double-Acting

Blade lift (1), Steering (1) .... 4.0 in dia. (101,6 mm)

HYDRAULIC VALVE: (1) combination steering and blade; two-spool with built-in, adjustable main relief valve.

STEERING SYSTEM

Articulated frame; full hydraulic power steering, lever-type control.

CYLINDER: One (1) double-acting, interchangeable with blade lift cylinder. Steering valve has fine metering and two (2) separate overload relief valves.

WINCH (Clark WD-200)

Rated capacity, lbf (kN)	24 000 (106,8)
Maximum linepull (baredrum), lbf (kN)*	22 880 (101,8)
Maximum line speed (baredrum) fpm (m/min)*	375 (114,3)

Mechanically driven "live" shaft; torque converter automatically adjusts power/speed for linepull up to maximum without shifting gears while standing or moving. Hydraulically controlled; winch prop shaft does not rotate unless winch drive clutch engaged. Sealed winch housing has self-contained lubricating oil supply; self-adjusting for wear with external adjustment for freespool drag.

*Based on 90% efficiency with 0.50 in (12,7 mm) dia. rope.

DRUM CAPACITY (Wire Rope)

0.50 in dia. – 396 ft	(12,7 mm dia. – 120,7 m)
0.62 in dia. – 276 ft	(16,0 mm dia. – 84,1 m)
0.75 in dia. – 192 ft	(19,1 mm dia. – 58,5 m)

WEIGHT (Approx. Shipping)

Front axle, lb (kg)	9 790 (4450)
Rear axle, lb (kg)	6 680 (3036)
Total, lb (kg)	16 470 (7486)
Maximum approved field ready weight, lb (kg)	23 000 (10 432,6)

STANDARD EQUIPMENT

ALTERNATOR – 12V, 61A
AXLES – CLARK PLANETARY
BELLY GUARDS, FULL LENGTH KEEL SHAPED
BLADE, UTILITY
BUCKET SEAT, ADJUSTABLE
DIFFERENTIALS, NO-SPIN – FRONT AND REAR
FAIRLEAD – WITH 3 ROLLERS
FAN, PUSHER
FENDERS, REAR WRAP-AROUND
INSTRUMENTS/GAUGES
- Electrical gauges for:
  - Ammeter
  - Hourmeter
- Mechanical gauges for:
  - Engine coolant temperature
  - Engine oil pressure
  - Torque converter temperature

MUFFLER
SAFETY RELATED
- Canopy. FOPS (SAE J231) ROPS (SAE J1040)
- Circuit breaker, electrical system main
- Disconnect switch, battery
- Fire extinguishers, twin 5 lb (2,3 kg)
- Neutral start switch
- Seat belt (SAE J386)
- Steering frame lock (SAE J276)

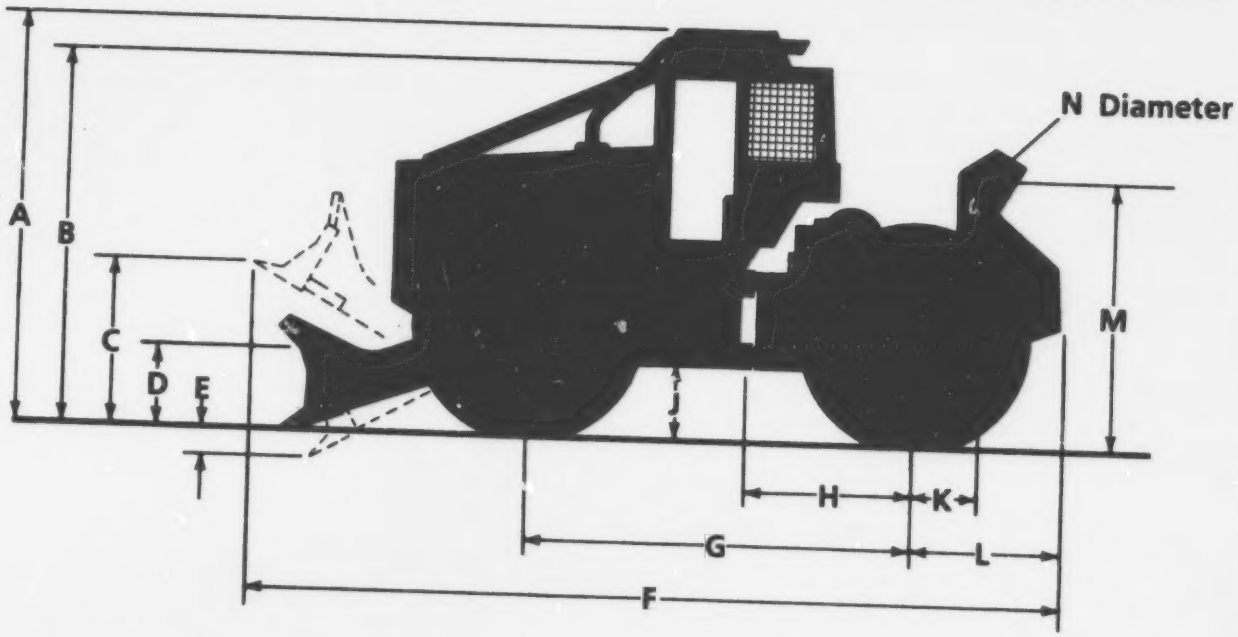
SIDE PANELS, ENGINE COMPARTMENT
TIRES – 18.4-34, 16PR (LS-2) (UNITED)
TORQUE CONVERTER – CLARK
TRANSMISSION – 3 SPEED, FULL REVERSING CLARK POWERSHIFT
WARNING LIGHT
- Parking Brake

WINCH – CLARK WD-200

MACHINE DIMENSIONS

Turning Radius in (mm) 205.5 (5219,7)
Width Over Tires, in (mm) 103.75 (2636,5)
Track, Front & Rear, in (mm) 83.75 (2128,5)
Blade Width, in (mm) 84 (2133,6)

664D
Cable Skidder



TIRES		A	B	C	D	E	F	G	H	J	K	L	M	N
18.4-34 STD	in	116.0	106.8	47.0	23.3	6.2	220.0	110.0	45.0	20.6	18.8	41.5	77.0	8.6
	mm	2946,4	2712,7	1193,8	591,8	157,5	5588,0	2794,0	1143,0	523,2	477,5	1054,1	1955,8	218,4
18.4-26	in	112.0	102.8	43.0	23.3	10.2	220.0	110.0	45.0	16.6	18.8	41.5	73.0	8.6
	mm	2844,8	2611,1	1092,2	591,8	259,1	5588,0	2794,0	1143,0	421,6	477,5	1054,1	1854,2	218,4
23.1-26	in	114.1	104.9	45.1	23.2	8.5	220.0	110.0	45.0	19.6	18.8	41.5	74.7	8.6
	mm	2898	2664,5	1146	591,8	215,9	5588,0	2794,0	1143,0	497,8	477,5	1054,1	1897,4	218,4
28.1-26	in	116.0	106.8	47.0	23.3	7.7	220.0	110.0	45.0	20.6	18.8	41.5	75.8	8.6
	mm	2946,4	2712,7	1194	591,8	195,6	5588,0	2794,0	1143,0	523,2	477,5	1054,1	1925,3	218,4

OPTIONAL EQUIPMENT

OPS CANOPY (Operator Protection System) (SAE J1084) Includes:
- Doors, mesh
- Front screen, mesh

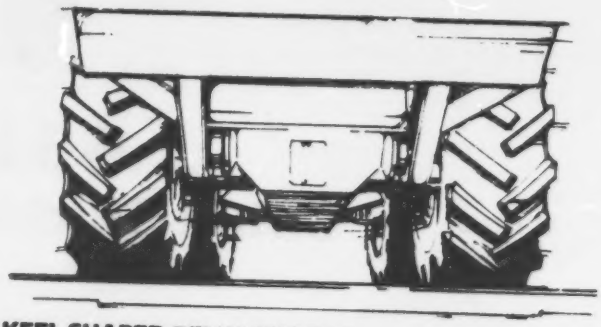
GENERAL OPTIONAL EQUIPMENT
- Axles, heavy duty
- Block heater, engine
- Brake, secondary
- Cable cutter
- Fairlead, optional (8" higher, 4" further back from rear axle)
- Fan kit, suction
- Light kit, work
- Roller, fairlead fourth
- Steering, secondary
- Throttle, hand
- Tow hook
- Wheel wrench
- Wheel wrench handle

RIGGING (for use outside North America only)
- Hardwood rigging package
- Pulpwood rigging package

TIRE OPTIONS

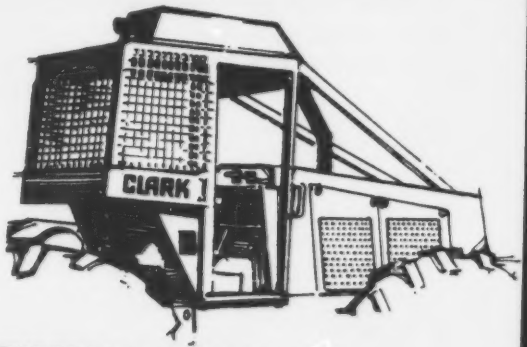
Available in lieu of standard tires

- 18.4-26, 10PR (LS-2)
- 18.4-34, 10PR (LS-2)
- 23.1-26, 10PR (LS-2)
- 23.1-26, 16PR (LS-2)
- 24.5-32, 12PR (LS-2)
- 24.5-32, 16PR (LS-2)
- 28.1-26, 10PR (LS-2)
- 28.1-26, 10PR (LS-3)
- 28.1-26, 16PR (LS-2)



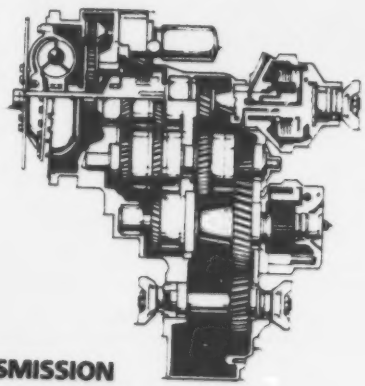
KEEL SHAPED BELLY GUARDS

Guards provide full length protection for drivetrain components in front and rear frame sections. The keel shaped design gives the 664D flotation in soft or muddy terrain. All serviceable items are accessible through bolt-on plates.



SQUARE BACK CANOPY

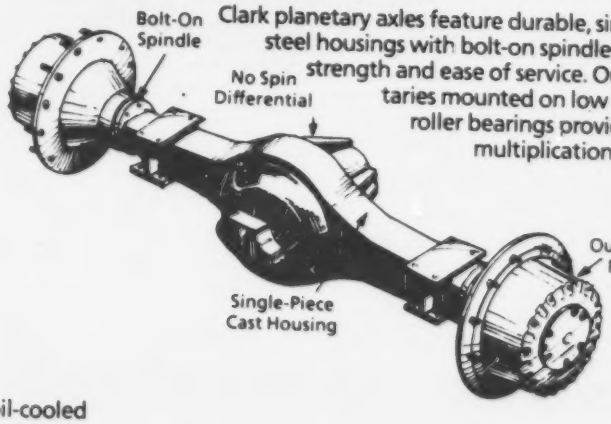
The canopy provides protection and plenty of elbow room. Wire mesh side panels plus side brush guards keep brush and overhanging branches from hitting the operator. Kits meeting OPS requirements may be fitted to the canopy; see Optional Equipment.



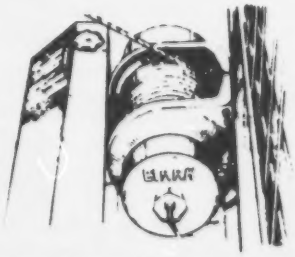
TRANSMISSION

The Clark powershift transmission with integral torque converter offers three forward and reverse speeds.
The compact countershaft design incorporates an oil-cooled multi-disc service/parking brake system and a winch drive clutch.

PLANETARY AXLES



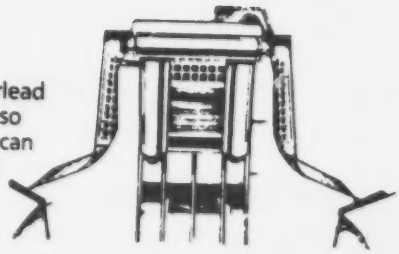
Clark planetary axles feature durable, single-piece, cast steel housings with bolt-on spindles for maximum strength and ease of service. Outboard planetaries mounted on low friction needle roller bearings provide final torque multiplication at the wheels.



WINCH

The Clark WD-200 winch is a simplified design which requires no adjustments for wear. All winching operations are controlled by hydraulically activated clutches and the winch has its own oil supply to reduce lines crossing the hinge area. Driven from the transmission, the winch prop shaft rotates only when the control lever is activated; this feature reduces wear and minimizes vibration. The hydraulic control valve has three positions: 1. WINCH-IN, 2. LOCK, and 3. FREESPOOL. The control lever automatically returns from the WINCH-IN to the LOCK position for safety.

FAIRLEAD



The 664D fairlead is positioned so the operator can easily see the load. A large 8.6 in (218,4 mm) straight main roller reduces cable stress for longer life; main and 4.0 in (101,6 mm) side rollers turn on lubricated bearings. All roller bearings and pins are interchangeable. An optional top roller (as shown) is available; a raised fairlead that provides 8.0 in (203,2 mm) more height is also available.

Specifications subject to change without notice or obligation.
Illustrations used in this publication may include optional equipment.

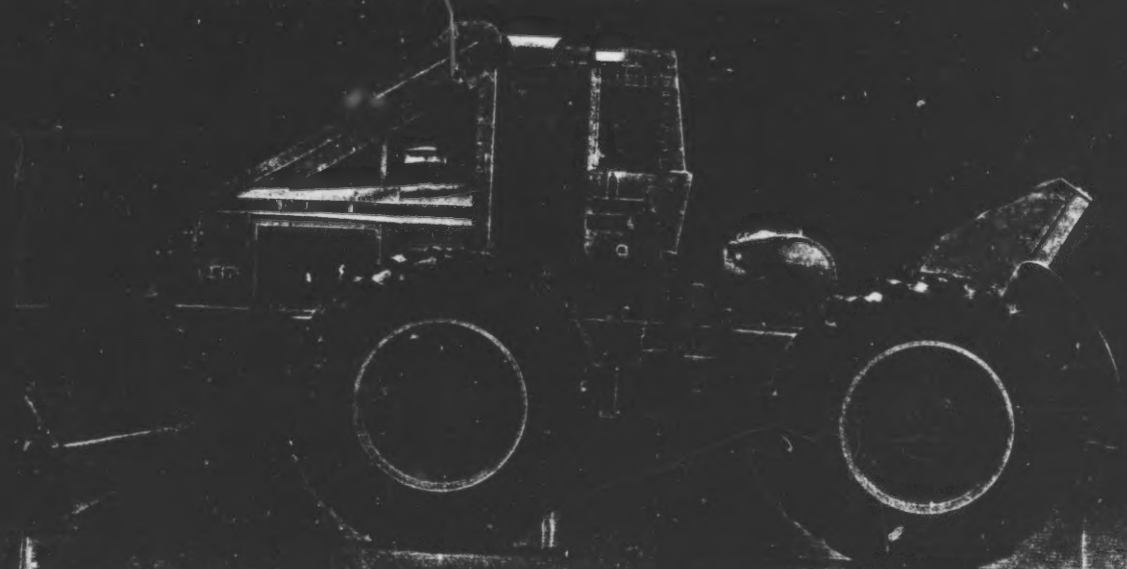
CS664D-CP DEC 83 Printed in U.S.A.

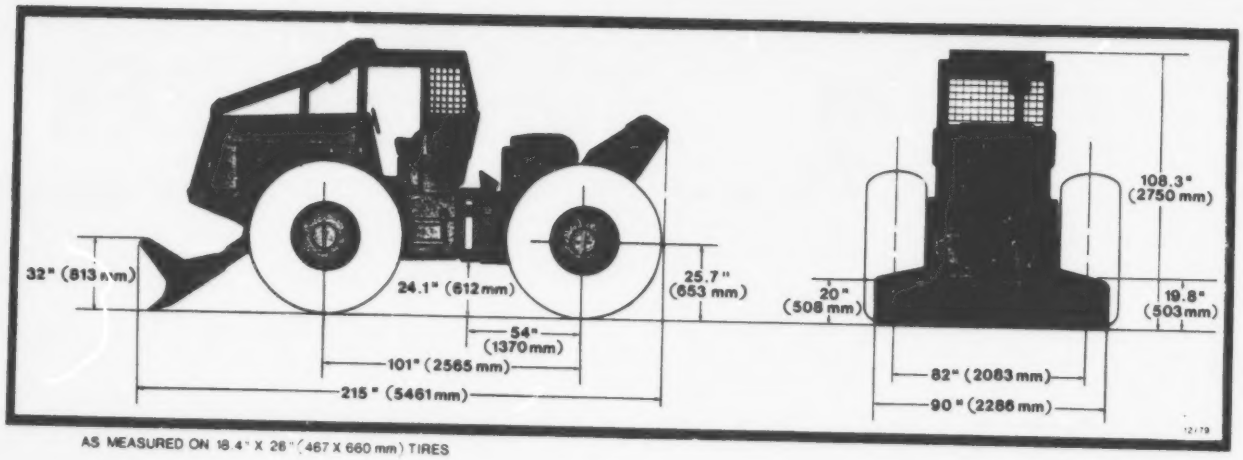
CLARK Construction Machinery Division

TREE FARMER

DIRECT DRIVE
100 HP CLASS

- 4 speed synchromesh transmission
- Constant mesh, 2-speed, full reversing transfer case
- "No-Spin" differentials and outboard planetary gearing on front and rear axles
- Controlled flow hydraulic steering — adjusts for any speed
- Large diameter tapered hinge pins
- Central lubrication system
- Optional diesel engines — Deutz air cooled or General Motors liquid cooled
- 20,000 lb. capacity winch allows winching on the fly and in forward and reverse gears





AS MEASURED ON 18.4" X 26" (467 X 660 mm) TIRES

TREE FARMER C5D DIRECT DRIVE 100 HP CLASS

SPECIFICATIONS

ENGINE (Diesel)

	GM 3-53	Deutz F5L 912
Rated horsepower	92	100
Net flywheel horsepower	82	90
Full load governed RPM	2800	2650
Number of cylinders	3	5
Bore	(98.4mm) 3.875"	(100mm) 3.937"
Stroke	(114.3mm) 4.5"	(120mm) 4.720"
Displacement	(2.61 litres) 159 cu. in.	(4.71 litres) 287.4 cu. in.
Fuel	No. 2 fuel oil	No. 2 fuel oil
Fan	Pusher	Suction

INSTRUMENTS AND GAUGES

Ammeter, hourmeter, oil pressure, engine temperature gauges, air cleaner restriction indicator, brake warning light, 12 volt electrical system, and master disconnect switch.

CLUTCH

Mechanically actuated.
Heavy duty spring loaded (305mm) 12" diameter plate.

TRANSMISSION

4 speed synchromesh (all gears)
Gear ratios 1st 6.32:1 2nd 3.09:1 3rd 1.68:1 4th 1.0:1

TRANSFER CASE

Constant mesh two speed reversing.
Ratios: High 1.01:1 Low 1.48:1

AXLES (RP12/10 Planetary or equivalent)

Four wheel drive. Front and rear "No-Spin" differential.
Axle ratio 30.64:1
Front axle oscillation ground to tire ..... (533.4mm) 21"

BRAKES

Service: Foot operated -- internal expanding. Capacity: (2710 N-m) 2000 ft. lb. hot. Mechanical parking brake.

TIRES (standard)

(467 X 864mm) 18.4" X 34" (Canada)
(467 X 660mm) 18.4" X 26" (US)
(467 X 660mm) 18.4" X 26" (Export)

SPEEDS (467 X 660 mm/18.4" X 26" tires)

Gear:	1st		2nd		3rd		4th	
Deutz	mph	kmh	mph	kmh	mph	kmh	mph	kmh
Low	1.48	2.38	3.03	5.31	4.01	6.45	9.40	15.12
High	2.11	3.39	4.50	7.24	8.28	13.32	13.9	22.37
GM								
Low	1.57	3.81	3.21	5.16	5.92	9.58	9.93	15.98
High	2.22	5.41	4.76	7.66	8.74	14.06	14.7	23.65

CAPACITIES

Cooling system (GM) ..... (18.2 litres) 4 Imp. gal., 4.8 US gal.
(Deutz -- air cooled).
Hydraulic tank ..... (50 litres) 11 Imp. gal., 13.2 US gal.
Fuel system ..... (90.8 litres) 20 Imp. gal., 24 US gal.

HYDRAULICS

Direct drive pump:
..... GM (113.6 L) 25 Imp/30 US gal/min at 2650 RPM
..... Deutz (106 L) 23 Imp/28 US gal/min at 2800 RPM
Steering cylinder (No-Shock) ..... (89 X 515mm) 3.5" X 20.25"
Dozer cylinders ..... (89 X 356mm) 3.5" X 14"
Working pressure ..... (12,070 kPa) 1750 PSI

STEERING

Hydraulic powered articulated frame steering.
Turning radius outside tire ..... (4.75m) 15' 7"

WINCH

Can Car 20, hydraulically controlled, mounted on rear frame.
Winch drum diameter ..... (215.9mm) 8.5"
Winch drum length ..... (228.6mm) 9"
Winch drum flange depth ..... (89mm) 3.5"
Cable capacity ..... (71m of 16mm dia.) 232' of 5/8" cable

LOGGING ARCH

Optional locations. Fabricated construction with two vertical and a large horizontal fairlead rollers mounted on sealed anti-friction bearings.

WEIGHT

Front	4,635 kg	10,217 lbs.	66%
Rear	2,387 kg	5,263 lbs.	34%
Total	7,022 kg	15,480 lbs.	100%

STANDARD EQUIPMENT

Deluxe seat, removable wire mesh engine side panels, removable canopy, dozer blade (2286 X 508mm) 90" X 20", hand throttle, dry type air cleaner, muffler/spark arrestor, full flow hydraulic oil filter, central lubrication, tool box under seat, 12 volt batteries (2), alternator, cigar lighter, anti-freeze (GM), fire extinguisher, seat belts, and operators and parts manuals.

OPTIONAL EQUIPMENT

Suction fan in addition to pusher (GM), optional tire sizes, engine heater, Gearmatic 19 winch, RP23/16 axle (rear, front, or both), 24 volt starting (Deutz), 5 speed transmission, disc brakes, dual disc brakes, top fairlead roller, fenders, large fenders, fenderettes, wheel steering, rubber mounted lights, enclosed cab with wipers, heater and defroster, dual steering, and rear frame reinforcement for grapple.

Tree Farmer reserves the right to change specifications without incurring any obligations

Hawker Siddeley Canada INC.
FORESTRY EQUIPMENT DIVISION
P.O. BOX 1004, MALTON POSTAL STN., MISSISSAUGA ONTARIO L4T 3Y1

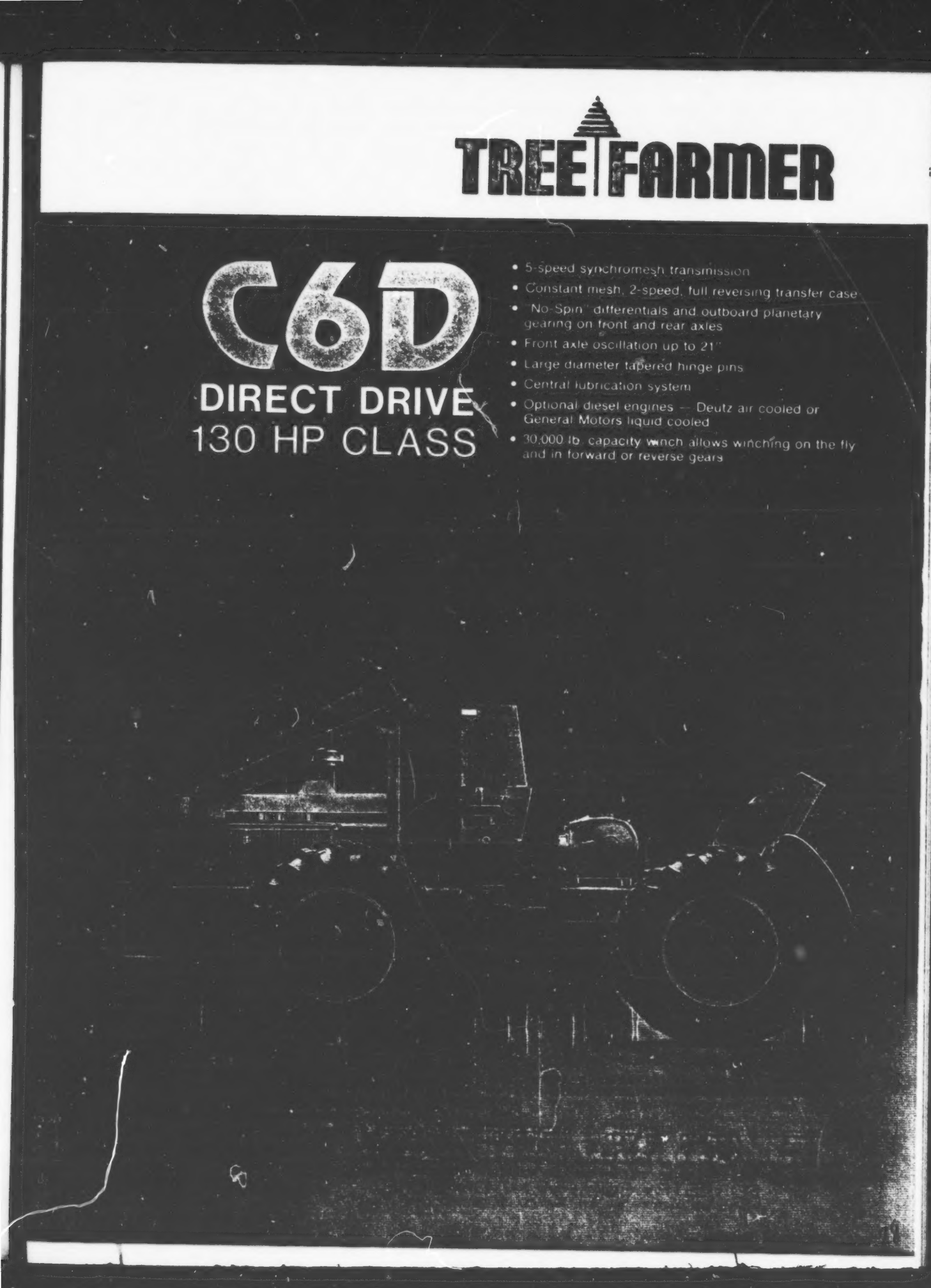
PRINTED IN CANADA JUNE 1980

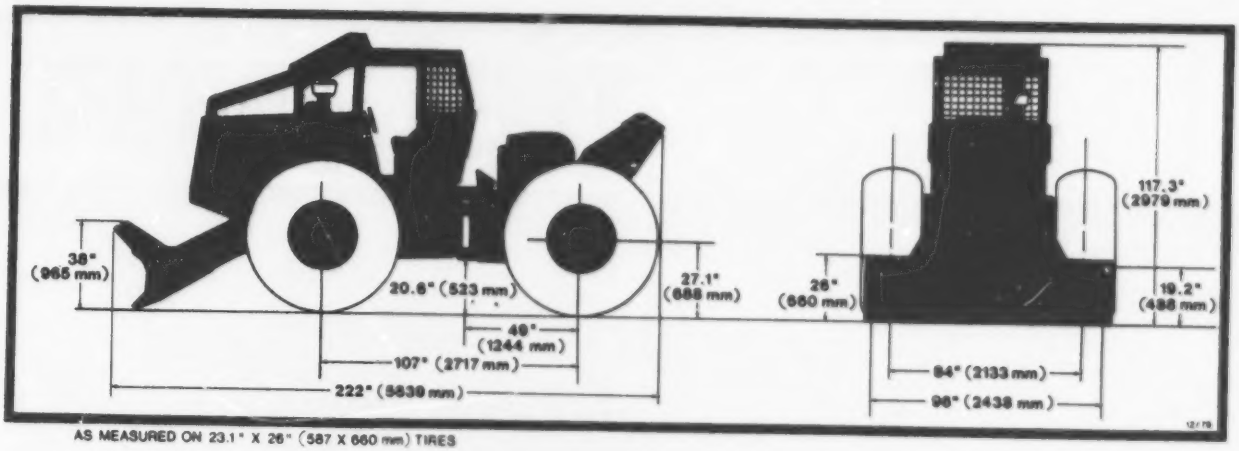
TREE FARMER

C6D

DIRECT DRIVE
130 HP CLASS

- 5-speed synchromesh transmission
- Constant mesh, 2-speed, full reversing transfer case
- "No-Spin" differentials and outboard planetary gearing on front and rear axles
- Front axle oscillation up to 21°
- Large diameter tapered hinge pins
- Central lubrication system
- Optional diesel engines — Deutz air cooled or General Motors liquid cooled
- 30,000 lb. capacity winch allows winching on the fly and in forward or reverse gears





AS MEASURED ON 23.1" X 26" (587 X 660 mm) TIRES

TREE FARMER C6D DIRECT DRIVE 130 HP CLASS

SPECIFICATIONS

ENGINE (Diesel)

	GM 4-53	Deutz F6L 912
Rated horsepower	127	120
Net flywheel horsepower	117	116
Full load governed RPM	2800	2650
Number of cylinders	4	6
Bore	(98.4mm) 3.875"	(100mm) 3.937"
Stroke	(114.3mm) 4.5"	(120mm) 4.72"
Displacement	(3.5 litres) 212 cu. in.	(5.7 litres) 345 cu. in.
Fuel	No. 2 fuel oil	No. 2 fuel oil
Fan	Pusher	Suction

INSTRUMENTS AND GAUGES

Ammeter, hourmeter, oil pressure, engine temperature gauges, air cleaner, restriction indicator, brake warning light, and master disconnect switch.

CLUTCH

Mechanically actuated.
Heavy duty spring loaded (355.6mm) 14" diameter single plate.

TRANSMISSION

5 speed synchr mesh.
Gear ratios: 1st 7.24:1 2nd 4.53:1 3rd 2.61:1 4th 1.59:1 5th 1:1

TRANSFER CASE

Constant mesh two speed full reversing.
Ratios: High 1.06:1 Low 1.53:1

AXLES (RP 23/16 Planetary or equivalent)

Four wheel drive. Front and rear "No-Spin" differential.
Axle ratio 30.46:1
Front axle oscillation ground to tire ..... (546mm) 21.5"

BRAKES

Service: Foot operated hydraulic disc brakes. Capacity: (5150 N-m) 3800 ft. lb. hot. Mechanical parking brake.

TIRES (standard)

(467 X 864mm) 18.4" X 34" (Canada)
(587 X 660mm) 23.1" X 26" (US)

SPEEDS (587 X 660 mm / 23.1" X 26" Tires)

Gear:	1st		2nd		3rd		4th		5th	
GM	mph	kmh	mph	kmh	mph	kmh	mph	kmh	mph	kmh
Low	1.46	2.35	2.25	3.62	3.74	6.02	6.14	9.88	9.72	15.64
High	1.95	3.14	3.26	5.25	5.39	8.67	8.84	14.42	14.05	22.61
Deutz										
Low	1.38	2.22	2.13	3.43	3.54	5.70	5.81	9.35	9.20	14.80
High	1.85	2.98	3.09	4.97	5.10	8.21	8.37	13.47	13.30	71.40

CAPACITIES

Cooling systems ..... (27.2 litres) 6 Imp. gal., 7.2 US gal.
Hydraulic tank ..... (50 litres) 11 Imp. gal., 13.2 US gal.
Fuel tank ..... (145 litres) 32 Imp. gal., 38 US gal.

HYDRAULICS

Direct drive pump:
- Deutz ..... (106L) 23 Imp/28 US gal/min at 2650 RPM
- GM (113.6 L) 25 Imp/30 US gal/min at 2800 RPM

Steering cylinder (2) (No-Shock). ..... (89 X 515mm) 3.5" X 20.25"
Dozer cylinders ..... (102 X 515mm) 4" X 14"
Working pressure ..... (12,070 kPa) 1750 PSI

STEERING

Wheel type, controlled flow, hydraulic powered, articulated frame steering.
Turning radius outside tire ..... (519mm) 17"

WINCH

Can Car 20, hydraulically controlled, mounted on rear frame.
Winch drum diameter ..... (215.9mm) 8.5"
Winch drum length ..... (228.6mm) 9"
Winch drum flange depth ..... (88.9mm) 3.5"
Cable capacity ..... (71m of 16mm dia.) 232' of 5/8" cable.

LOGGING ARCH

Option locations. Fabricated construction with two vertical and a large horizontal fairlead rollers mounted on sealed anit-friction bearings.

WEIGHT

Front	5,442 kg	11,999 lbs.	66%
Rear	2,804 kg	6,181 lbs.	34%
Total	8,246 kg	18,180 lbs.	100%

STANDARD EQUIPMENT

Deluxe seat, removable wire mesh engine side panels, removable canopy, dozer blade (2438 X 660mm) 96" X 26", hand throttle, dry type air cleaner, muffler/spark arrestor, full flow hydraulic oil filter, central lubrication, tool box under seat, 12 volt batteries (2), alternator, cigar lighter, anti-freeze (GM), wheel steering, fire extinguisher, s... belts, and operators and parts manuals.

OPTIONAL EQUIPMENT

Suction fan in addition to pusher (GM), optional tire sizes, engine heater, Gearmatic 19 winch, 24 volt starting (Deutz), dual disc brakes, fenders large, fenderettes, extra capacity pump, rubber mounted lights, enclosed cab with wipers, heater and defroster, and extended frame.

Tree Farmer reserves the right to change specifications without incurring any obligations

Hawker Siddeley Canada INC.
FORESTRY EQUIPMENT DIVISION
P.O. BOX 1004, MALTON POSTAL STN., MISSISSAUGA, ONTARIO L4T 3Y1

 PRINTED IN CANADA

CATERPILLAR

[redacted]

Summary of features

- **Cat 3304 diesel Engine** with 425 cu. in./7.0 liters displacement. Turbocharger eliminates need for spark arrester.
- **Oscillating frame** . . . excellent maneuverability, smooth ride and low center of gravity for good stability.
- **Choice of brakes** . . . driveline disc for level terrain or driveline and front wheel disc for slope work.
- **Operator and machine protection** . . . rollover protective structure with sweeps, screens and grab irons. Steel belly pans, bolt-on hydraulic hose guards and perforated engine side guards.
- **Operating ease** . . . power shift transmission with torque converter eliminates need for inching pedal. Three forward/reverse speeds cover entire work range. NoSPIN differentials automatically lock when needed — eliminating manual control. No hump to straddle in operator's compartment. Ample foot and knee room so operator can turn for winch operation.
- **Easy servicing** . . . no daily lubrication. Turn a valve to drain crankcase from the side. Sight gauges and dipsticks are easily accessible.
- **Ground clearance** of 22" 559 mm with 23.1×26 tires.
- **CAT PLUS Services** . . . from your Caterpillar Dealer . . . the most comprehensive, total customer support system in the industry.

Machine shown may have optional equipment.

[redacted] **Caterpillar Engine**

Flywheel power @ 2200 RPM 120 hp/89 kW
(Kilowatts (kW) is the International System of Units equivalent of horsepower.)

The net power at the flywheel of the vehicle engine operating under SAE standard ambient temperature and barometric conditions, 85° F/29° C and 29.38" Hg/995 mbar, using 35 API gravity fuel oil at 60° F/15.6° C, and after deductions for fan, air cleaner, water pump, lubricating oil pump, fuel pump, muffler, air compressor and alternator. Engine will maintain specified power up to 10,000 ft./3000 m altitude.

Caterpillar 4-stroke-cycle 3304 turbocharged diesel Engine with four cylinders, 4.75"/121 mm bore, 6.0"/152 mm stroke and 425 cu. in./7.0 liters displacement.

Caterpillar direct injection fuel system with individual adjustment-free injection pumps and valves. Valve rotators provide even heat distribution.

Cam-ground and tapered aluminum alloy pistons with 3-ring design, cooled by oil spray. Steel-backed aluminum bearings. Hi-Electro hardened crankshaft journals. Pressure lubrication with full-flow filtered and cooled oil. Dry-type air cleaner with primary and safety elements.

24-volt direct electric starting system. Optional ether aid is available for cold weather starting. 35-amp alternator. Four 120-amp-hour, 6-volt batteries.

90

518

Cable Skidder

transmission

Caterpillar planetary power shift with single-stage, single-phase torque converter.

Single lever on left of steering column controls both speed and direction. Lever locks transmission control in neutral. Machine will not move if started in gear.

Speeds with 18.4 x 34 tires (approximate)

	1st	2nd	3rd
Forward, MPH:	4.6	8.9	16.5
Km/h:	7.4	14.3	26.6
Reverse, MPH:	5.5	10.8	19.8
Km/h:	8.9	17.4	31.9

axles

Front and rear axles fixed to frame. NoSPIN differentials in front and rear.

final drives

All-wheel drive with planetary reduction in each wheel. Planetary units and axles can be removed independently of wheels.

tires (tube-type)

Standard tire — 18.4×34, 10 PR, (LS-2) steel breaker belt. See optional equipment list on back page for other tire sizes.

Machine can be ordered with rims installed for 81.5" **2070 mm** tread with 18.4×34 tires, 76" or 81.5" **1930 or 2070 mm** tread with 23.1×26 tires. With driveline and front wheel disc braking system, 23.1×26 tires are available with 81.5" **2070 mm** tread only. 28L×26 tires available with 81.5" **2070 mm** tread only.

frames

Two frames fabricated from steel plate, with formed sections and castings. Joined at the hitch by two hardened-steel pins, 2.75" **70 mm** in diameter. Manganese bronze sleeve-type upper bearing and double-tapered roller lower bearing. Horizontal radiator mounts allow radiator to flex independently of the radiator guard.

oscillation

Frame-type, with heavy-duty roller bearings at the hinge point. Total oscillation 28°/±14°.

steering

Articulated frame. Full hydraulic control, with specially designed steering bar for quick, easy maneuvering. Non-follow-up. Bar swings 30° left or right. Variable flow modulation: the more the steering bar is moved, the faster the machine articulates. The angle of articulation holds until the bar is steered in the opposite direction. Priority type steering.

Machine articulation (each direction) 45°

Turning radius (outside rear wheels, 18.4×34 tires) 17'3" **5.3 m**

Hydraulic system — Two 3.0" **76 mm** bore, double-acting cylinders powered by vane-type pump.

Output *@* 2340 RPM and
1000 psi **69 bar** 25.2 gpm **96 liters/min**
Relief valve setting 2700 psi **186 bar 18 616 kPa**

brakes

(System meets SAE J237.)

Service brakes — Driveline disc or driveline plus front wheel discs.

Driveline disc brake — Air oil-actuated caliper disc, 18" **457 mm** diameter, mounted on rear driveshaft of transmission.

Driveline and front wheel discs — Two front-wheel caliper discs, 19" **483 mm** diameter, in addition to the driveline disc. Air oil-actuation. Wheel brakes are actuated first, holding driveline in reserve for steep slopes or heavy loads.

Parking — Uses driveline disc brake. Air released and spring applied by control valve to right of seat.

arch

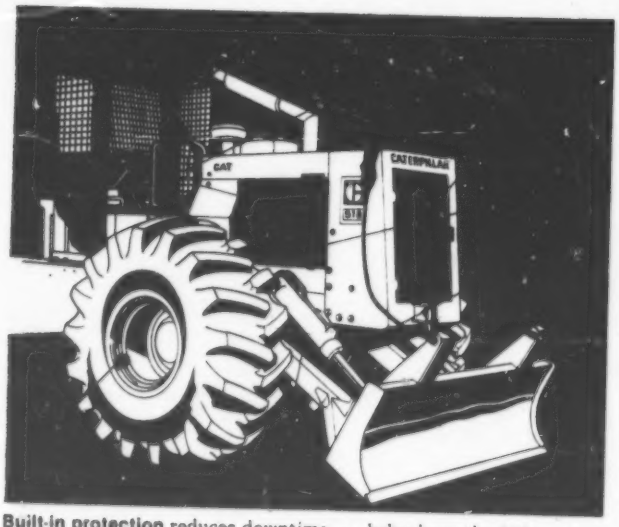
Fabricated steel, integral with butt plate and fenders. Fixed roller position. Hardened, contoured main roller is Life-time Lubricated, 7.5" **190.5 mm** middle diameter, 9.75" **247.7 mm** edge diameter. Side rollers are hardened steel.

winch

Gearmatic Model 119 — hydraulically controlled and mechanically driven off torque converter.

Line pull (maximum at stall) 32,000 lb. **14 520 kg**
Line speed (*@* rated engine RPM) 234 fpm *@* 10,800 lb.
71 m/min @ 4900 kg
Maximum line speed (bare drum) 435 fpm/**133 m/min**
Drum capacity 235'/**72 m** of 5/8"/**16 mm** wire rope.

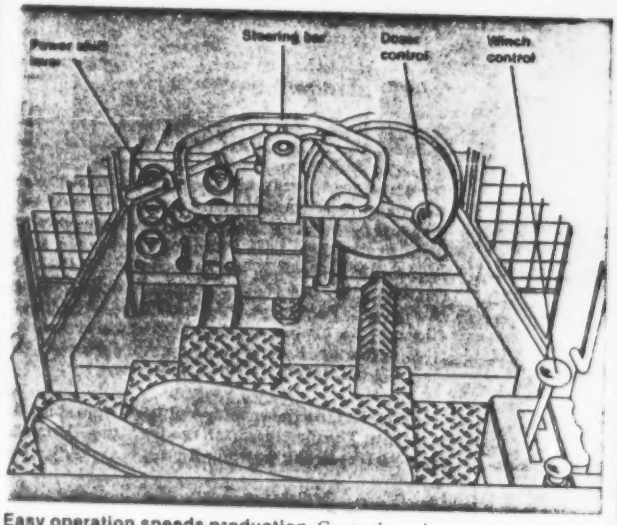
Operator and machine protection.



Built-in protection reduces downtime . . . helps keep the 518 moving even on the tough jobs.

- Standard ROPS canopy meets OSHA regulations for strength and clearance.
- Dozer cable guards (kicker cables) eject any log rolling over the dozer just by lowering the blade.
- Belly pans are high strength steel fabrications . . . bolted to the main frame.
- Brush guards on front of platform screen machine from limbs.
- Drive line guarding in oscillating hitch area helps protect drive and hydraulic lines from damage.
- Lift-out engine enclosures and hinged radiator guard help protect engine components.
- Butt plate and wrap-around fenders aid in withstanding pounding from logs.

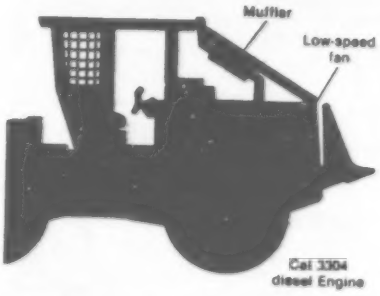
Built-in convenience and comfort mean oper



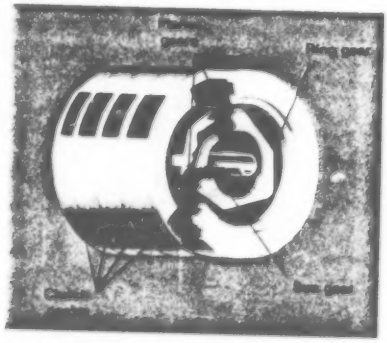
Easy operation speeds production. Controls and gauges are grouped for operator efficiency and productivity.

- Single lever on steering column controls speed and direction. Rotate handle to select three speeds in forward and reverse. Move lever forward or back for direction changes.
- Variable flow modulated steering responds precisely for roading or maneuvering around trees and stumps.
- Winch and dozer controls are conveniently located at operator's right.
- Operator sits high in an adjustable seat canted 15° to the right for good visibility front and rear.

Cat power train — efficient and responsive.



Turbocharged Cat 3304 diesel Engine powers the 518. The four-stroke-cycle, large muffler and low-speed fan mean low noise levels. Cat direct injection fuel system needs no adjusting. Turbocharging packs power and breaks up sparks eliminating need for a spark arrester.



Rugged planetary power shift lets you change speed and direction on the move. Big clutch packs are hydraulically modulated for smooth engagement . . . oil cooled for long work life. Torque loads are spread out over three planetary gears . . . not concentrated on a single countershaft gear.

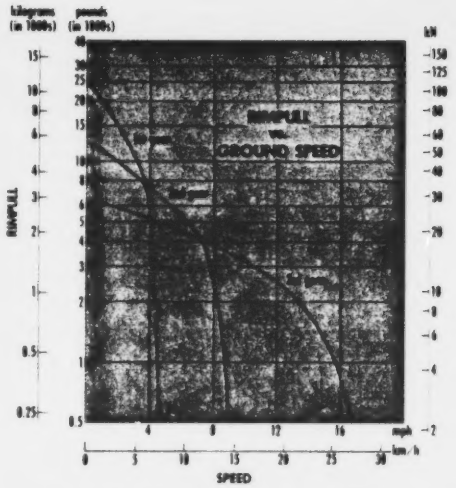
The right tools for the job.

Gearmatic Model 119 Winch has line pull to 32,000 lb. 14 520 kg. It's driven off the torque converter. And a socket helps prevent tip-overs by releasing the cable when it's reeled out completely.

standard equipment

ROPS canopy. Winch. Fairlead with main and two side rollers. Backup alarm. Bulldozer blade and hydraulics. Bulldozer cylinder guards. NoSPIN differential (front and rear). Integral underguards, bolted to axle housing and main frame. Brush guard group. Hinged radiator guard with lift-out screen. Rear fenders. Rear view mirror. Adjustable seat. Seat belt. Driveline disc brakes. Parking brake. Transmission lever. 35-amp alternator. Muffler. Dry-type air cleaner with precleaner. Engine enclosures (perforated). Blower fan. Fan guard. Electric horn. Air cleaner service indicator. Low air pressure warning horn. Visual hydraulic oil level indicator. Fuel priming pump. 18.4×34, 10 PR (LS-2) steel breaker belt tires. Water separator.

Gauges: Engine water temperature. Engine oil pressure. Fuel pressure. Torque converter temperature. Ammeter. Electric hour meter. Brake warning light.



*Standard tires. Usable rimpull depends on traction, tire size and equipped weight of loaded skidder.

optional equipment

(with approximate change in operating weight.)

	Lb	Kg
Brake system, heavy duty	100	45
Cable cutter	10	5
Ether starting aid	20	9
Fairlead top roller	110	50
Fan, reversible blade	20	9
Heater, cab	35	16
Heater, engine coolant	3	1.4
Lighting system, 2 front and 2 rear	30	14
Low temperature starting motor	47	21
ROPS cab (enclosed; glazed)	1150	522
ROPS cab (enclosed; screen)	1100	500
Steering, supplemental, ground driven	246	112
Tires and tubes, set of four:		
Logger (LS-2), 10 PR:		
23.1×26 steel breaker belts	240	109
28L×26 steel breakers belts	1370	621
Tire, tube and rim, spare one:		
Logger (LS-2), 10 PR tire and rim, steel breaker belts:		
18.4×34	640	290
23.1×26	650	295
28L×26	940	426
Tool kit	18	8.2
Vandalism protection:		
Instrument panel guard	10	5
Caplocks for:		
Oil filler	1	0.5
Oil dipstick	1	0.5
Fuel tank	2	1.0
Hydraulic tank	3	1.4
Wiper/washer	11	5

Materials and specifications are subject to change without notice.

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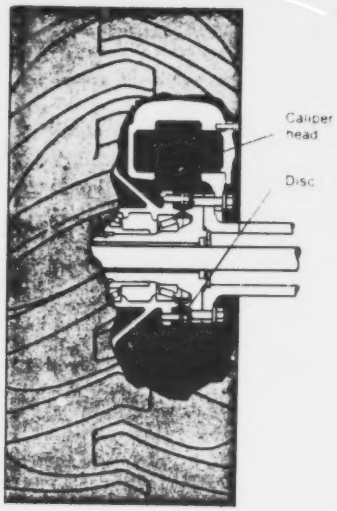
or efficiency.

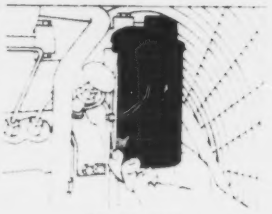


Caliper disc brakes deliver dependable stopping power. They're fade-resistant and externally mounted for cooling. No need for adjustment. Choose driveline disc brake for level ground work, or driveline and front wheel discs for work on slopes.

Serviceability — reduced time on maintenance, increased time on the job.

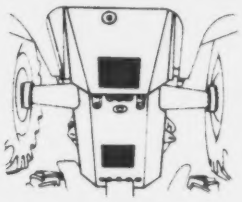
Hinged radiator guard

Lift out engine enclosures

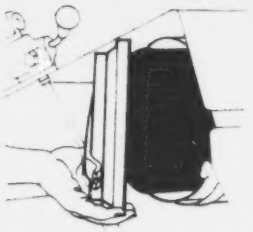


Spin on filters

Crankcase drainage



Belly pan access hole

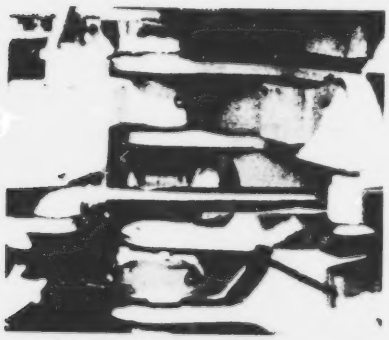


Dry type air cleaner

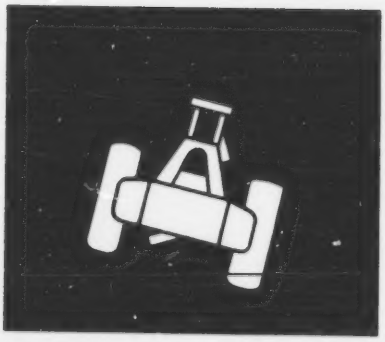
Maintenance is simplified on the 518:

- No daily lubrication is required and you can work up to 50 service hours between lubes.
- Drain the crankcase oil by simply turning a valve on the side of the engine. No need to crawl underneath.
- Check transmission fluid level from inside the operator's compartment.
- Fuel and oil filters spin on or off for easy replacement and are disposable canisters.
- Access ports in the belly pan allow quick clean out of brush and debris.
- Radiator guards are hinged for easy access.
- Perforated engine enclosures help reduce trash build-up and lift out for quick access.
- Service the air cleaner element from inside the operator's compartment . . . an indicator on the dash signals when

Rugged components for rugged work.



45° articulated steering makes maneuvering quick and easy. And it's dependable . . . two hardened-steel pins couple the frames. A manganese bronze bushing encloses the upper pin; a double-tapered roller bearing, the lower.



Frame oscillation lets each end of the 518 ride over bumps independently. Heavy duty roller bearings at the hinge point allow front or rear frame to oscillate a total of 28° (±14°) with respect to the opposite end.

dozer

Fabricated steel, arms mounted directly to main frame structure. Heat-treated cutting edge. Flared junction at box-section push arm and blade to reduce stress. Maintenance-free pivot joints. Two end-mounted cylinders, 4.0" **102 mm** bore, 14.0" **356 mm** stroke. Dozer hydraulic hoses protected by steel bolt-on guards. Controlled by lever to right of steering column.

weight (approximate)

Operating — includes lubricants, coolant, full fuel tank, bulldozer, driveline and front wheel disc brakes, winch, cable, ROPS canopy and operator 21,300 lb. **9662 kg**

Maximum unloaded operating weight should not exceed 24,500 lb. **11 110 kg**.

service refill capacities

	U.S. Gallons	Liters
Fuel tank	38	144
Cooling system	9.5	36
Crankcase	5	19
Transmission and torque converter	8.5	32
Differential and final drives:		
Front	7.2	27
Rear	7.2	27
Hydraulic system	7.5	28
Winch	1.5	5.7

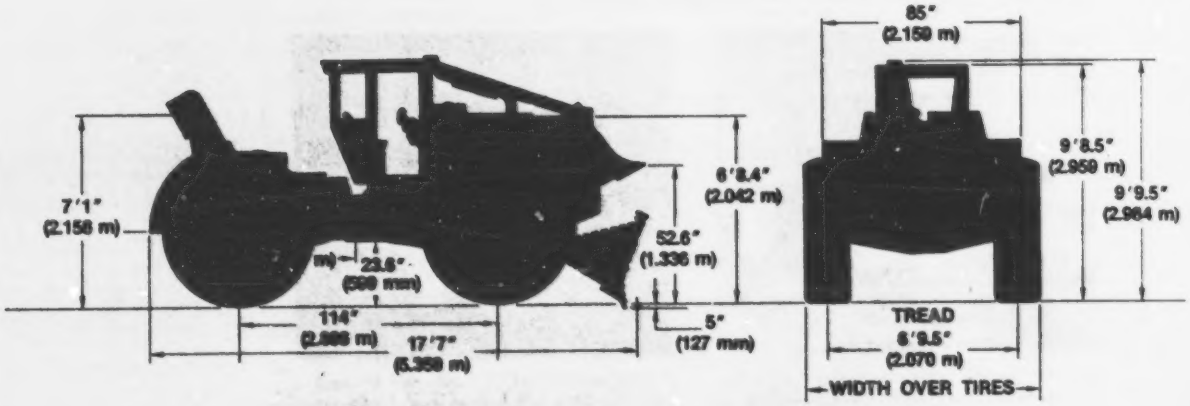
ROPS

(ROPS canopy is standard)

ROPS (Rollover Protective Structure) offered by Caterpillar for this machine meets ROPS criteria: SAE J394, SAE J1040a and ISO 3471. It also meets FOPS (Falling Object Protective Structure) criteria SAE J231 and ISO 3449.

machine dimensions

	18.4 x 34 tires	23.1 x 26 tires	28L x 26 tires
Tread	81.5" (2.070 m)	76" or 81.5" (1.930 m or 2.070 m)	81.5" (2.070 m)
Width over tires	8'3" (2.510 m)	8'3" or 8'8" (2.510 m or 2.640 m)	9'2" (2.790 m)
Clearance at hitch pin	24" (610 mm)	22" (559 mm)	22.5" (572 mm)



Appendix B

Mobile Whole-Tree Chipper Specifications

Specifications

Trelan Model C-14 Mobile Disc Chipper

Manufacturer:	Strong Maunfacturing Company 498 Eight Mile Road Remus, Michigan 49340
Type:	Mobile Disc Chipper, 1 Knife
Trailer Mounting:	1 axle trailer with pintle hitch, arranged for towing behind truck. Chip discharge chute points forward.
Disc Diameter:	1200 mm (48")
Disc Speed:	600 rpm.
Power Rating:	75 KW. (100 Hp.)
Power Source:	A 6 cylinder Ford gasoline engine or 120 Hp. Detroit Diesel 453, driving the disc through a 1/4 turn belt drive.
Maximum Diameter:	366 mm. (14")
Production Capacity:	9.1 tonne/hour (10 ton/hour)
Chip Lengths:	15-26 mm. (0.62" - 1.0") set at factory.
Infeed Rate:	15 m/min. (50 ft./min.) at 2.5 cm. chip length knife setting.
Weight:	4400 Kg. (9725 lbs.)
Features:	Equipped with hydraulic grapple laoder, hydraulically powered infeed rolls, Knives changed in 10 minutes.

MORBARK SUPER BEEVER

IDEAL FOR MUNICIPAL AND TREE DISPOSAL APPLICATIONS

A step up from Morbark's Eeger Beever, the Super Beever provides greater productive capabilities.

The larger infeed opening, increased horsepower and the unique open spout feed wheel system allows for chipping larger diameter material and greater volume of brush material. This makes the super Beever an ideal machine to dispose of wood and brush coming to a land fill or central chipping area.

Many municipalities confronted with an ever increasing volume of tree trimmings and brush, collect material with dump trucks and haul it to a central location or land fill. The Super Beever will reduce this material to wood chips and cause a significant reduction in material volume, thereby, reducing transportation, handling, dumping and land fill costs.

The compact design allows for chipping on city streets to clean up trees damaged from wind or ice storms. This versatility is also advantageous when municipal shade trees are affected by disease.

Like all Morbark chippers, the Super Beever produces a saleable dimensional chip. These chips are being sold for the following uses:

- Fuel - Energy
- Land fill cover and erosion control
- Landscape and nursery mulch
- Municipal park nature trails
- Sludge composting as a bulking agent
- Temporary road covering
- Right-of-Way Utility Crews clearing for power lines will find the Super Beever a very productive machine. The chips can be blown back on the right-of-way to control erosion and plant growth.

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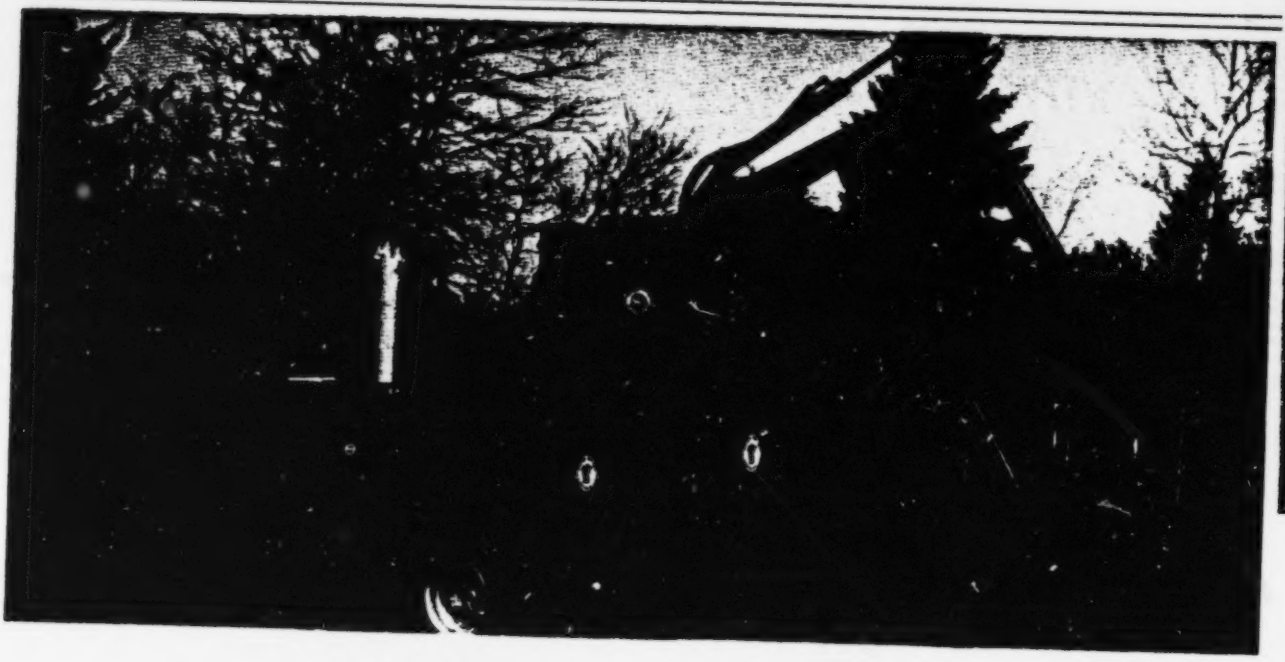
MORBARK SUPER BEEVER



A LOW PRICED MACHINE WITH A BIG APPETTITE

The Morbark Super Beever has been designed for harvesting applications requiring a low capital expenditure such as pine thinnings and the harvesting of logging residues. It is a truly rugged machine, built with production in mind, requiring a minimum capital investment.

CHIP 20" DIAMETER MATERIAL AND UP TO 200 TONS PER SHIFT

Average production of the Super Beever whole tree chipper is ranging between 100 and 200 tons per shift depending upon the ability to get wood to the machine and the quality of the material being chipped. The Super Beever will fill an average 40' van in a little over an hour.

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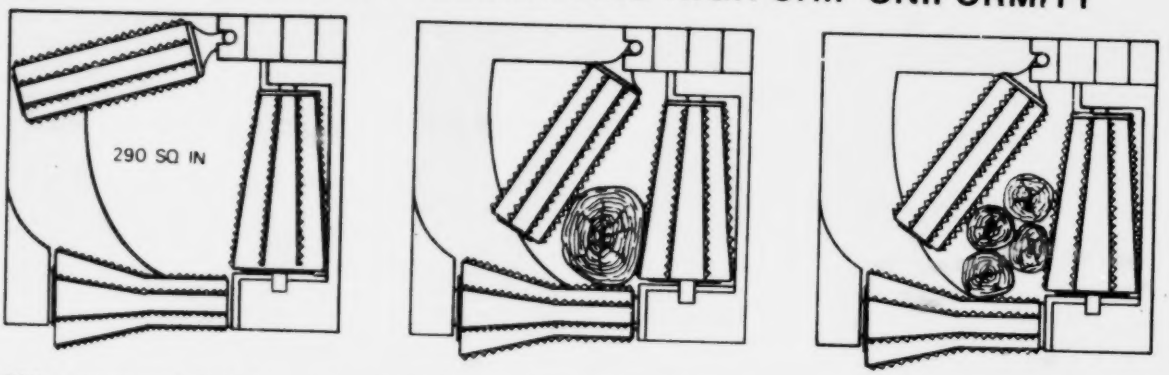
MORBARK SUPER BEEVER

THREE-WHEEL FEED SYSTEM PROVIDES GOOD LIMB COMPRESSION AND HIGH CHIP UNIFORMITY



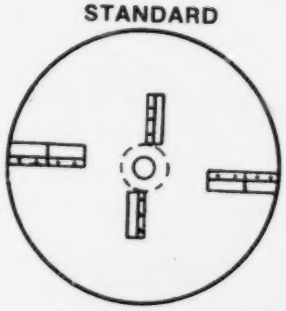
The 290 square inch spout opening on the Super Beever allows it to chip a 20" diameter tree or up to four 5" stems at one time. A hydraulic knuckle boom loader effectively feeds the Super Beever. The Morbark Model 100 Hydraulic Knuckle Boom Loader has more than adequate lifting and pulling capabilities.

The Model 100 Back Style Loader:

- Swings in a 100 degree arc
- Has a reach of 10'6"
- Will lift 2,000 pounds at 10'
- Pull 3,100 lbs.

NOTE: All figures at 2000 PSI setting

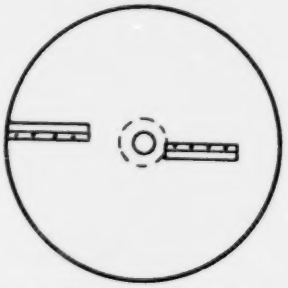
STANDARD



Two cuts per revolution. Consists of six 7" knives. Two 7" knives butt up together on the outer rim of the disc on opposite sides. The remaining two knives are positioned opposite of each other at the hub.

Plenty of horsepower with a 195-HP Cummins Model 504 diesel engine. The Model 504 195-HP Cummins engine is more than adequate to power the standard two-knife staggered pattern chipper ideal for most applications. An optional one-knife chipper is also available for certain applications.

OPTIONAL



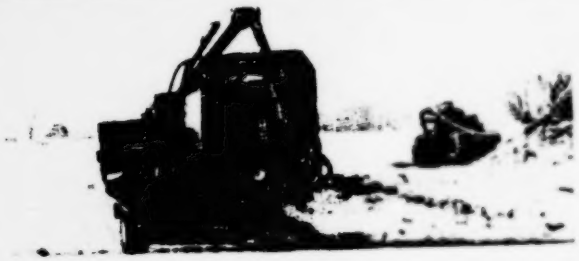
One cut per revolution. Consists of two 10" knives.

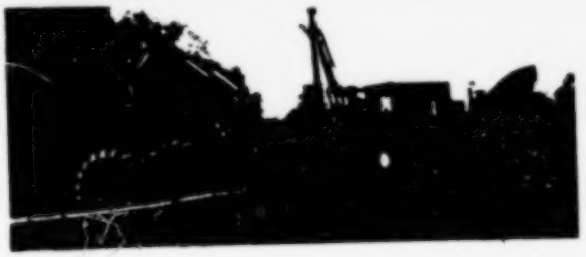
PRICES AND OPTIONS

SUPER BEEVER

Cummins 504 195-HP V8 Diesel	$13,500.00
Caterpillar 3208 N/A 210-HP Diesel	$13,500.00
Spare Parts Kit	$ 1,000.00
Hot Water Heater	$ 395.00
Combination Air Conditioner and Heater Unit	$ 1,770.00
7" Super Beever Knives	$ 21.37

MORBARK SUPER BEEVER





Ideal for first thinnings of forest residues:

- Its relative low cost
- Its ability to chip limby material
- Its ability to chip multiple stems
- Its ability to handle up to 20" diameter material
- Its compact size
- Its ease of operation
- Its simple design

Ideal for a three-man operation utilizing:

- Mark IV Mor-Bell Feller Buncher
- Mor-Bell Logger or grapple skidder
- Morbark Super Beever

Three men and three machines will produce up to 150 tons of material per day.

SPECIFICATIONS

GENERAL INFORMATION

Length	
Loader Closed	22'6"
Loader Open	27'6"
Width	8'0"
Height	8'6"
Total Weight (Dry Weight)	12,500 lbs.
Tongue Weight (Dry Weight)	2,500 lbs.
Axle Weight (Dry Weight)	11,000 lbs.
Boom Reach From Feed Wheels	10'6"

MAIN POWER UNIT AND DRIVE SYSTEM

Engine	Cummins V-504-C Diesel (195 HP)
Clutch	Twin Disc SP-211-HP
Engine RPM	2800
Fuel tank capacity	250 gallons
Drive sheaves	5V8.5" to 5V28.0"
Drive belts	(6) 5V-140"

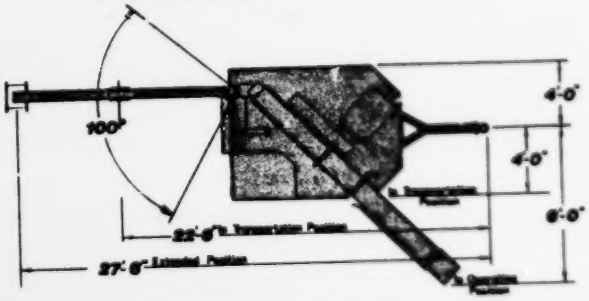
NOTE: Other engine options may be available in the near future, consult Morbark for price and availability.

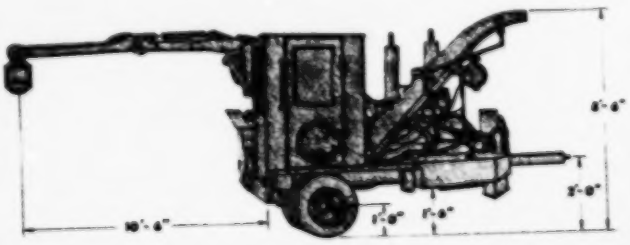
CHIPPER UNIT

Number of knives	2 (staggered pattern)
Disc diameter	52"
Disc RPM	850 (At 2800 engine RPM)
Lineal feed rate per minute	(3/4" chip)—106'
Number of fan blades	4

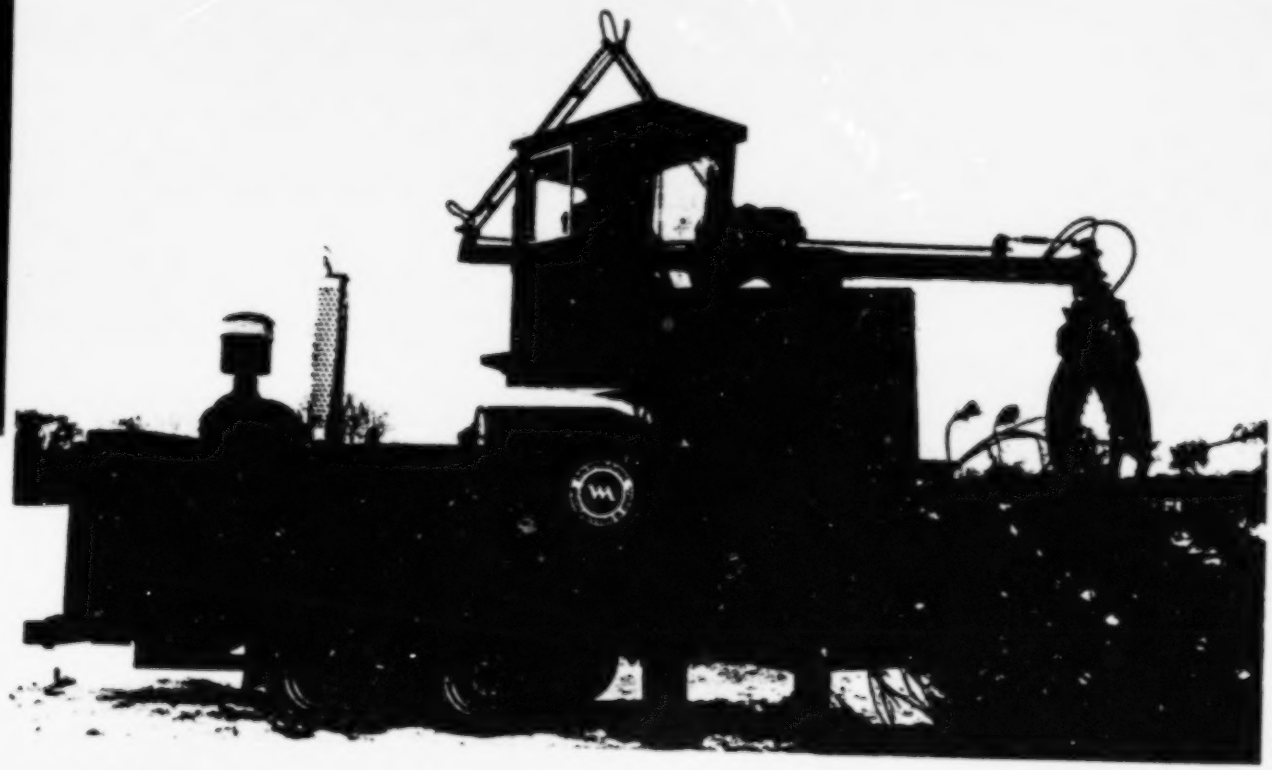
FEED SYSTEM AND HYDRAULIC POWER

Loader Power	Vickers Double Pump
Feed Power	Vickers Double Pump
Feed Wheels	(1) Stationary side wheel vertically mounted and (1) Stationary bottom wheel horizontally mounted. (1) Movable feed wheel that works in a swinging arc to hold material in feed position. The wheel holds a constant 500 PSI on the material and up to 2000 PSI for crushing power. Each wheel is individually driven by hydraulic motors.
Hydraulic tank capacity	65 gallon with spin-on type hydraulic filters





MORBARK MODEL 20 TOTAL CHIPARVESTOR



THE MODEL 20 TOTAL CHIPARVESTOR IS CAPABLE OF PRODUCING UP TO 400 TONS PER SHIFT

CAN CHIP 20" DIAMETER MATERIAL—

CHIPPER OPENING IS 20" VERTICALLY AND 24" DIAGONALLY

WILL FILL A 40' CHIP VAN IN LESS THAN 15 MINUTES

The famous Morbark Dirt Separator available on the Model 20 removes:

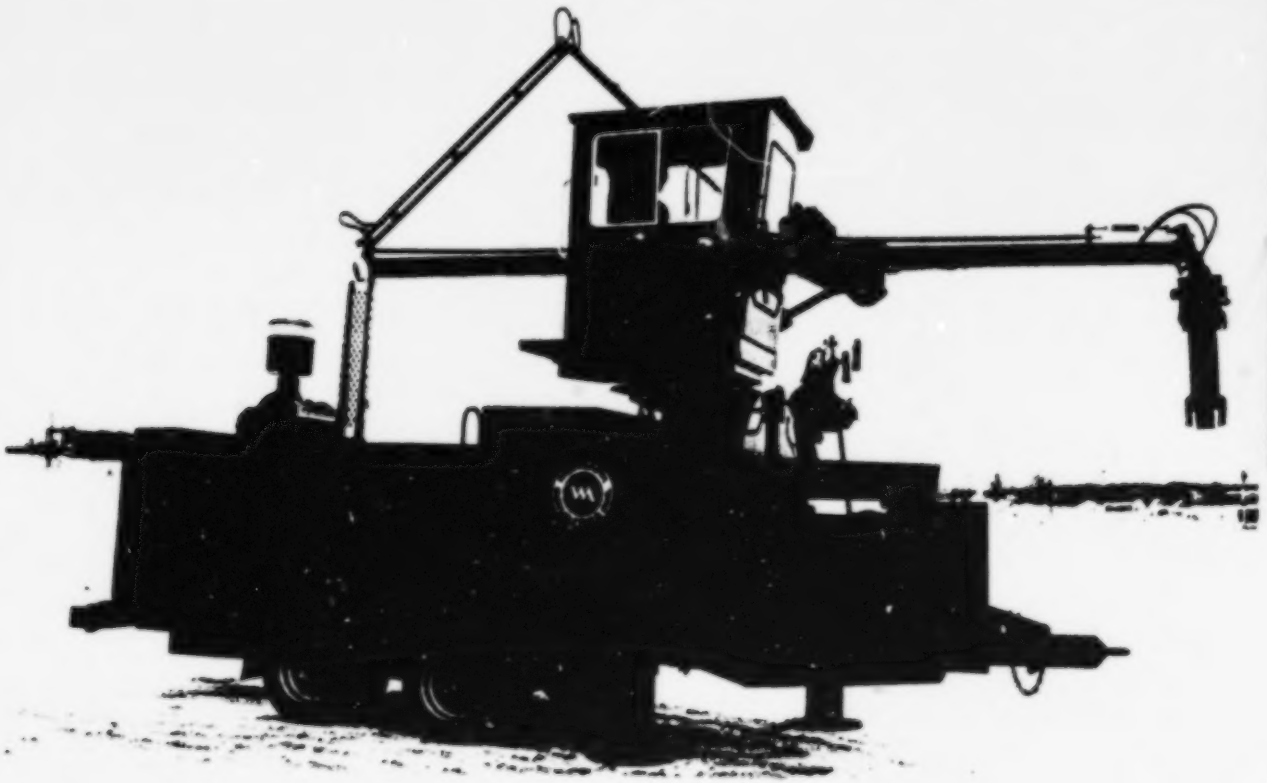
- 90% of the sand and grit
- 50% of the bark
- 50% of the twigs and foliage.
- **NO** acceptable chips

Plenty of Chipping Power With Low Fuel Consumption

One power unit supplies all the power to this self-contained machine.
The VT903 350-HP Cummins power unit supplies 175-HP per knife to this 2-knife machine.
The Cummins power plants provide:

- Unsurpassed fuel economy - 4 to 5 tons of chips per gallon of fuel consumed
- **One Year Warranty** on VT-903 provided by Cummins
- Custom registry with **four year extended warranty** on the major engine components. See Chiparvestor Power Section.

MORBARK MODEL 20 TOTAL CHIPARVESTOR



A HIGH PRODUCTION MACHINE PRICED TO MEET EVERY LOGGER'S BUDGET

The Model 20 was designed to meet the needs of the chip producer interested in **high production** in material **20" in diameter** or less.

Because of its open spout chipper design, the Model 20 can efficiently **chip limby trees** as well as pine or hardwood.

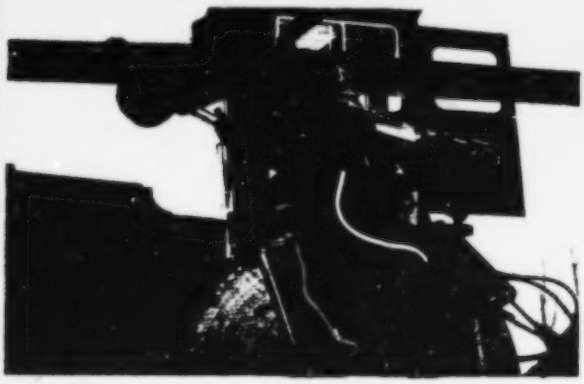
This rugged, heavy duty machine was designed for **high availability** and **low down time.**

The Model 20 is a compact, portable unit that is **easily transportable** with **quick set up time.**

Because of its ability to produce high quality chips, maintain high production levels, handle large diameter material and its price, there is nothing else on the market that can match the Model 20 for cost effectiveness.

With our demonstration facilities in Winn, Michigan, we invite you to witness how the Model 20 can operate under actual working conditions for the type and size of wood that you would encounter in your operation. We know that the Model 20 Total Chiparvestor can do the job for you.

MORBARK MODEL 20 TOTAL CHIPARVESTOR



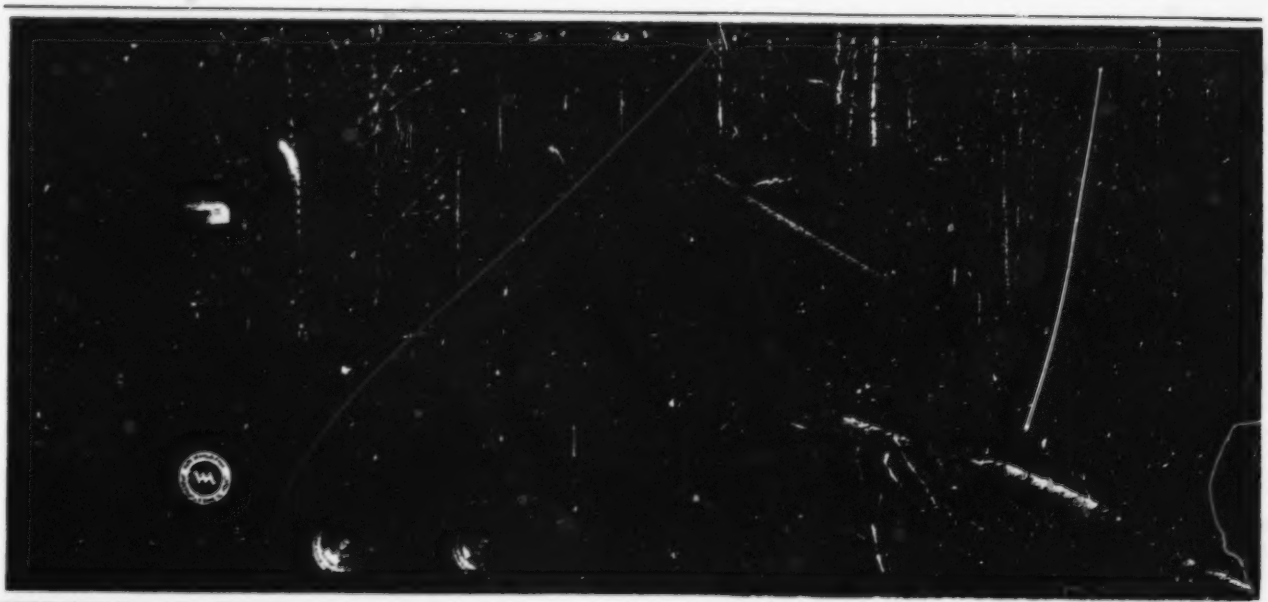
MISCELLANEOUS INFORMATION

- Hydraulic powered stabilizers on both sides of machine to raise and lower tongue for easy hook-up to pulling vehicle
- Safety locks on the clutch, chipper disc and top feed wheel pivot arm
- Includes a knife gauge and babbiting tools to allow the re-setting of used chipper knives and thus ensure consistent chip size

PRICES AND OPTIONS

MODEL 20 TOTAL CHIPARVESTOR

Dirt Separator	$1,050.00
Spare Parts Kit	$4,500.00
Model 20 Chipper Knives	$ 42.27
Model 20 Counter Knives (2-1/4")	$ 31.83
Spare Tire and Rim	$ 295.00
30' Long Spout Extension	$4,375.00
Combination Air Conditioner and Heater Unit	$1,770.00
Hot Water Heater ONLY	$ 370.00
Self-Contained Air Compressor	$3,025.00
5th Wheel to Pintle Hitch	$ 640.00



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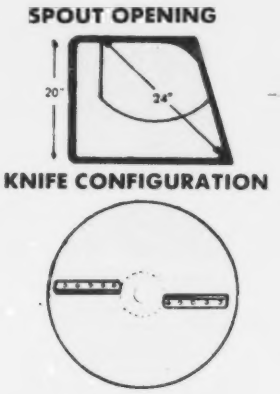
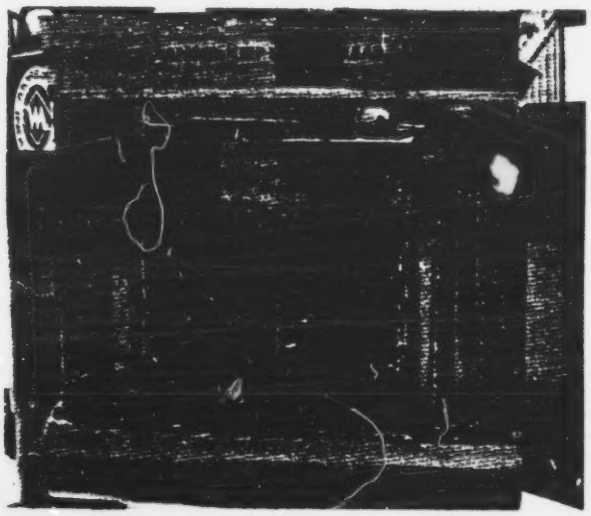
MORBARK MODEL 20 TOTAL CHIPARVESTOR

SPECIFICATIONS

CHIPPER UNIT

Number of knives 2
Disc diameter ..... 58"
Diameter capacity ..... 20"
RPM 738
Lineal feed rate per minute (7/8" chip) ..... 108'
Approximate maximum production in tons per 10 hour shift 450
Normal production per shift 200-300
Approximate time to load a 40' van ... 15-20 min.
Horsepower per knife 175





HYDRAULIC SHAFT MOUNTED GEAR MOTORS HAVE ELIMINATED THE CHAIN DRIVES

All four wheels are hydraulically powered by way of shaft mounted gear box reducers. They have replaceable gripping teeth and are mounted on self-aligning 2-15/16" bearings. Each wheel develops up to 25,000 in lbs. of torque powered by (2) Vickers double pumps. Each wheel is on an independent hydraulic circuit for easy maintenance

Feed Wheel Opening ..... Horizontal 24"
Adjustable Vertical 3/4" to 20"

The top wheel is hydraulically powered up and down for easier feed and crushing power on limby material.

Hydraulic tank capacity ..... 90 gal.

MAIN POWER UNIT AND DRIVE SYSTEM

Engine ..... Cummins VT-903 V8 Diesel
Horsepower (at 2600 RPM) 350
Dual Fuel Tank Capacity (each with filler caps) 80
Engine Operating RPM 2600
Water Coolant Capacity ..... 22 Gallon

GENERAL INFORMATION

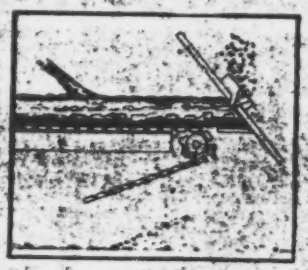
Length ..... 24'6"
Width ..... 9'0"
Height ..... 13'6"
Total Weight ..... 32,000 lbs.
Tongue Weight ..... 8,000 lbs.
Suspension Weight ..... 24,000 lbs.

TRELAN

MODEL:
D-60

STRONG
MANUFACTURING
COMPANY

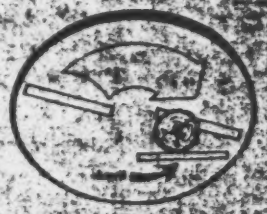
OUTSTANDING FEATURES O

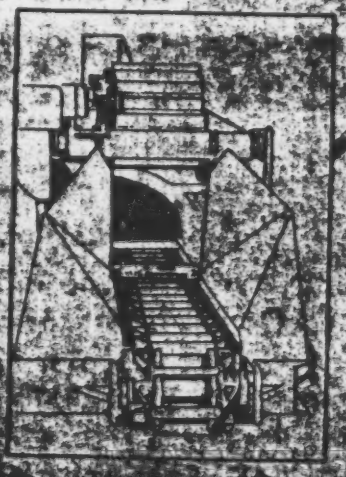


THE PROVEN DESIGN WITH ITS HORIZONTAL ANVIL, ELIMINATES A HIGH PERCENTAGE OF THE GRIT, SAND, LEAVES AND TWIGS THAT VIBRATE OFF THE TREE DURING THE CHIPPING PROCESS. THIS MATERIAL DROPS THROUGH THE OPENING IN FRONT OF THE HORIZONTAL ANVIL THEREBY IMPROVING CHIP QUALITY AND EXTENDING KNIFE LIFE.

LOWER OPERATING
HYDRAULIC SYSTE
UTILIZING THE AIR S
CHIPPER. THIS INC
AND ADDS LIFE TO
HOSES AND SEALS.

THE KNIFE POSITIONING TENDS TO DRAW THE WOOD TOWARD THE CENTER OF THE CUTTING BAR WHERE IT HAS A TORQUE ADVANTAGE AND REQUIRES LESS POWER TO COMPLETE THE CHIPPING PROCESS. THIS ACTION PRODUCES MORE EVEN WEAR ACROSS THE ENTIRE KNIFE EDGE. THE RINGED HOOD PROVIDES EASY ACCESSIBILITY TO HELP KEEP KNIFE CHANGING TIME TO A MINIMUM.



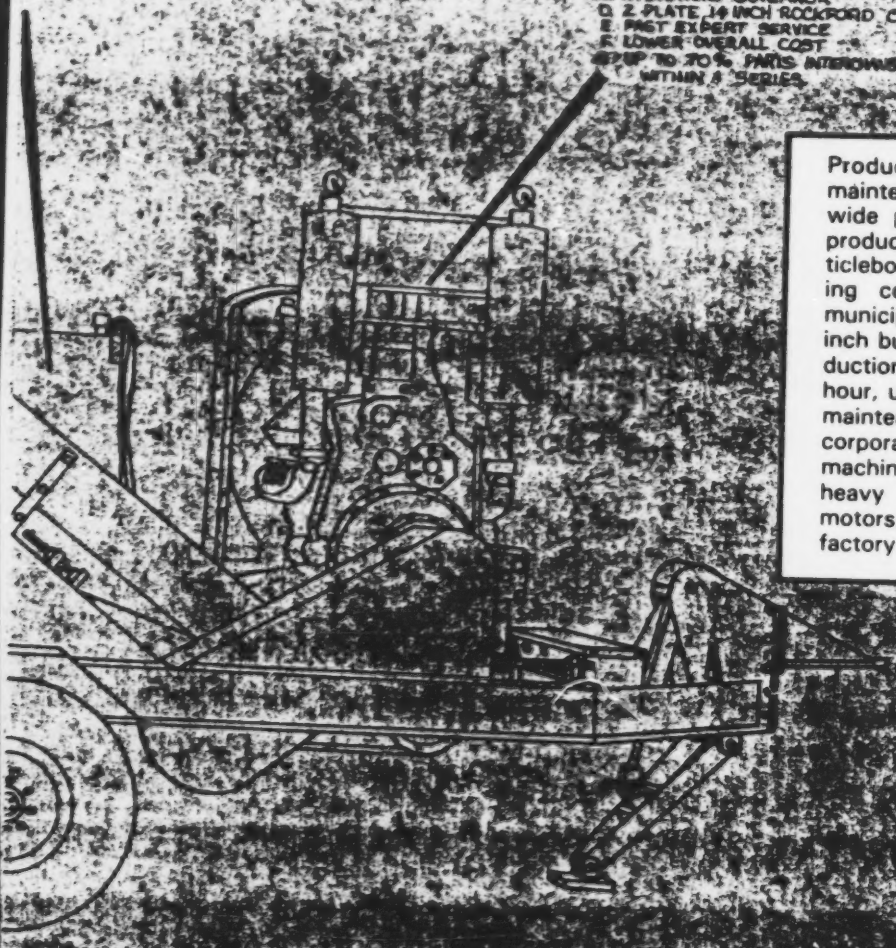


SPRING
FOUR 8:
FRAME
FORM FO

Ot

THE PATENTED 30 INCH TWO KNIFE CHIPPING DISC ELIMINATES WEIGHT WITHOUT SACRIFICING STRENGTH. LESS WEIGHT MEANS LESS TORQUE
FULL 12 INCH
CAPACITY.

F THE TRELAN MODEL D-60



Production reliability and proven low maintenance comes from years of world wide proven infield applications, whether producing quality wood chips for pulp, particleboard, hardboard, or chipping for clearing contractors, tree services or at a municipal land fill. Its ability to chip up to 18 inch butt diameter whole trees, makes production figures of 30 tons of chips per hour, under most conditions, a reality. Low maintenance stems from the fact that we incorporate quality components into each machine, from the diesel power units, to the heavy duty gear box, pump and drive motors, plus stringent quality control at our factory.

General Specifications

Length	21 ft. (6.4 M)
Width	8 ft. (2.4M)
Height	105" (2.74M)
Weight	18,300 lbs. (8,300 KG)
Chipper Disc	60", 2 knife
Capacity	18" dia. round wood
Feed Rate	75' per min. (¾" chip)
Production	30 ton per hr.
Power	GMC Diesel

Equipped with stop lights, tail lights, and turn signals.

STRONG MANUFACTURING COMPANY

[illegible] EIGHT MILE ROAD

[illegible] MICHIGAN 49340 U.S.A.

[illegible] 2280

[illegible] PATENTS U.S. [illegible] BELGIUM 818682, NEW ZEALAND 173309 [illegible] PATENTS PENDING

3

2

TREILAN

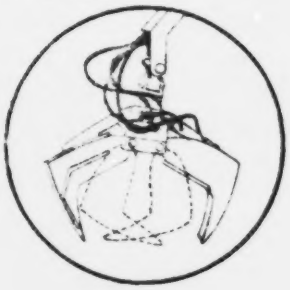
MODEL

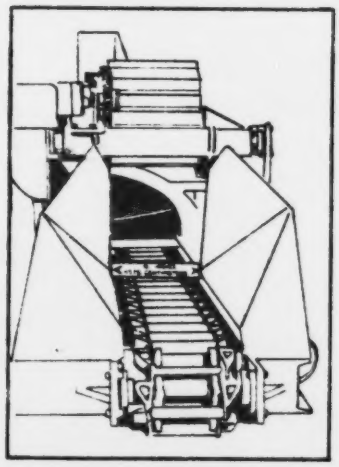
F91

OUTSTANDING FEATURES O

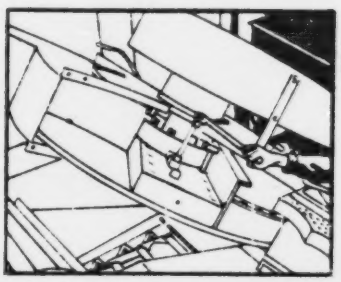
THE H-1000 FEATURES A LARGE DIAMETER SWING BEARING THAT IS DESIGNED TO SPREAD THE MAIN LIFT STRESS OF THE LOADER OVER A GREATER LOW STRESSED AREA THAN COMPARABLE MACHINES WITH 'NECKED-DOWN' SPINDLE DESIGNS.

THE BY-PASS GRAPPLE UNIT FEATURES A RUGGEDLY BUILT MOTOR OPERATED HEAD, HEAVY DUTY CYLINDERS AND FIELD TESTED JAW DESIGN WHICH CLOSES TO 3 INCHES.





THE NEW HI-TORQUE FEED SYSTEM SUPPLIES MORE THAN TWO AND ONE HALF THE FORCE OF PREVIOUS MODELS.



THE PATENTED 60 INCH TWO KNIFE CHIPPING DISC ELIMINATES WEIGHT WITHOUT SACRIFICING STRENGTH. LESS WEIGHT MEANS LESS TORQUE TO ACCELERATE, FASTER RECOVERY AND LESS WEAR ON BOTH THE ENGINE AND CLUTCH, WHILE STILL MAINTAINING FULL 18 INCH DIAMETER CHIPPING CAPACITY.

F THE TRELAN MODEL DL-18

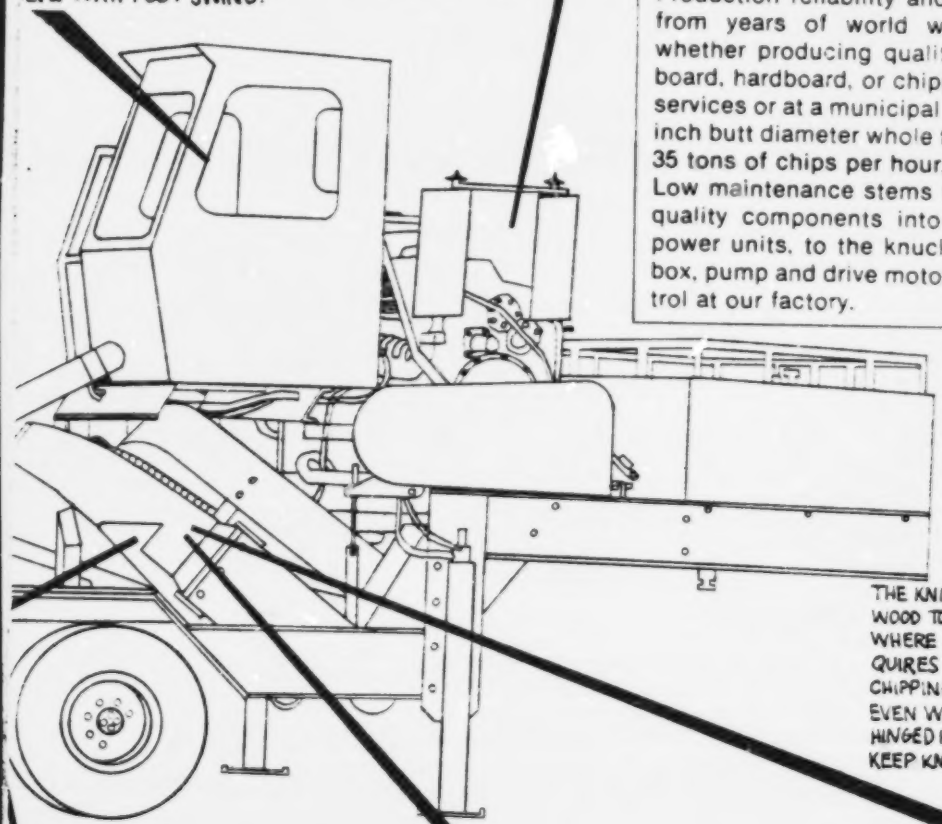
KLE-BOOM LOADER IS A HAWK H-1000 BUILT OF
ENGTH PLATE STEEL AND TUBING. THE MAIN
S POWERED BY AN OPPOSED PISTON RACK AND
NIT CAPABLE OF ROTATING THE BOOMS 270 DEGREES
OP TO STOP. THE PISTONS IN THE SWING UNIT ARE
D WITH HIGH QUALITY POLY TYPE SEALS THAT
TE SWING CYLINDER LEAKAGE.

L-WEATHER CAB CAN BE EQUIPPED WITH
VERAL OPERATOR COMFORTS. LOADER FUNCTIONS
E CONTROLLED BY A STACK TYPE SPOOL CONTROL
LVE WITH FOOT SWING.

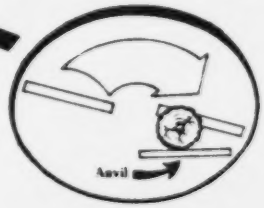
THE POWER IS PROVIDED BY AN 8V71 DETROIT DIESEL (318 H.P.)
WHICH OFFERS THE FOLLOWING FEATURES:

A. GREATER OVERALL LIFE EXPECTANCY
B. DEPENDABLE STARTING
C. HYDRAULIC GOVERNOR
D. 2 PLATE, 14 INCH ROCKFORD CLUTCH
E. FAST EXPERT SERVICE
F. LOWER OVERALL COST
G. UP TO 70 PERCENT PARTS INTERCHANGEABILITY WITHIN A SERIES

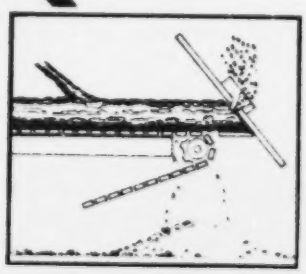
Production reliability and proven low maintenance comes from years of world wide proven infield applications, whether producing quality wood chips for paper, particle board, hardboard, or chipping for clearing contractors, tree services or at a municipal land fill. Its ability to chip up to 18 inch butt diameter whole trees, makes production figures of 35 tons of chips per hour, under most conditions, a reality. Low maintenance stems from the fact that we incorporate quality components into each machine, from the diesel power units, to the knuckle-boom loader, heavy duty gear box, pump and drive motors, plus very stringent quality control at our factory.



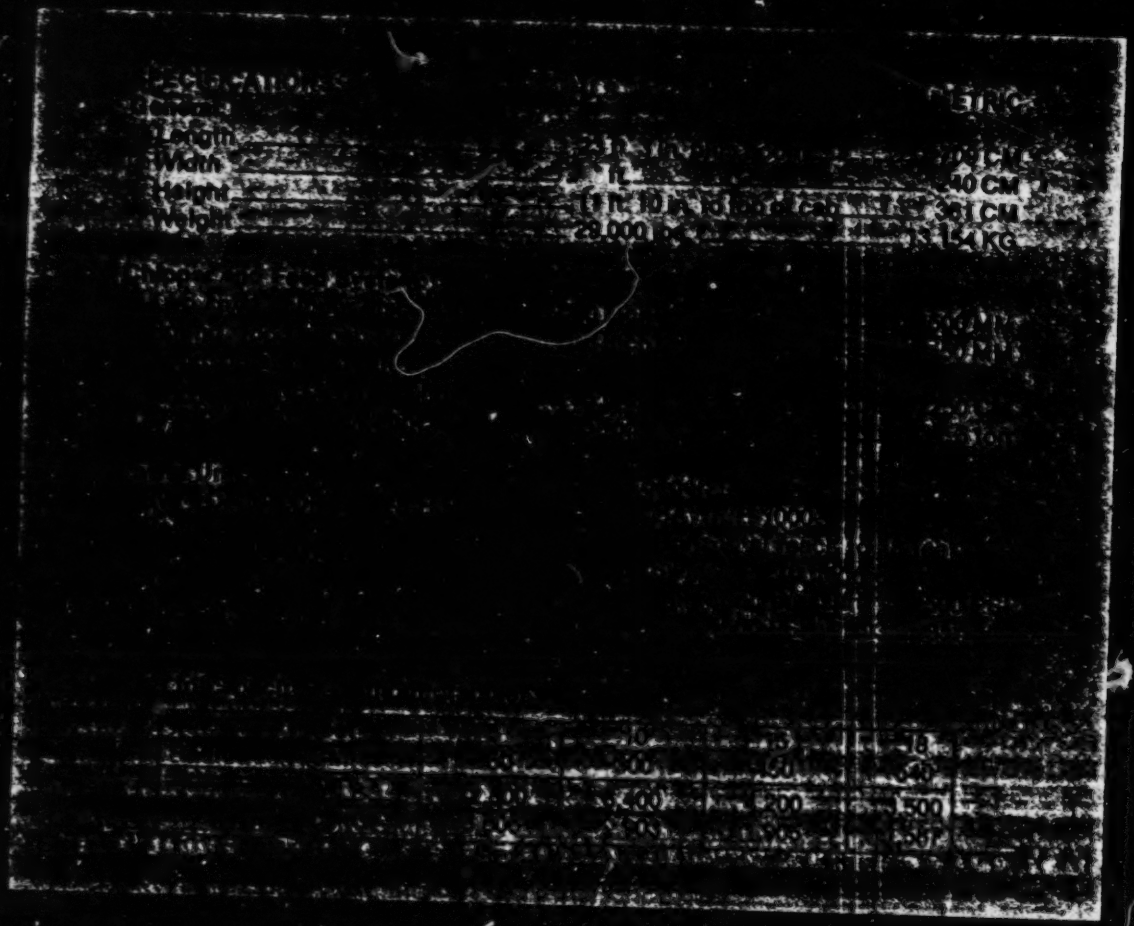
THE KNIFE POSITIONING TENDS TO DRAW THE WOOD TOWARD THE CENTER OF THE CUTTING BAR WHERE IT HAS A TORQUE ADVANTAGE AND REQUIRES LESS POWER TO COMPLETE THE CHIPPING PROCESS. THIS ACTION PRODUCES MORE EVEN WEAR ACROSS THE ENTIRE KNIFE EDGE. THE HINGED HOOD PROVIDES EASY ACCESSIBILITY TO HELP KEEP KNIFE CHANGING TIME TO A MINIMUM.



NTED TANDEM AXLE WITH FOUR
ES, 12 INCH CHANNEL FRAME AND
ILIZERS, PROVIDE A STRONG,
T FORM FOR THE CHIPPING OPERATION.



THE PROVEN DESIGN WITH ITS HORIZONTAL ANVIL, ELIMINATES A HIGH PECENTAGE OF THE GRIT, SAND, LEAVES AND TWIGS THAT VIBRATE OFF THE TREE DURING THE CHIPPING PROCESS. THIS MATERIAL DROPS THROUGH THE OPENING IN FRONT OF THE HORIZONTAL ANVIL, THEREBY IMPROVING CHIP QUALITY AND EXTENDING KNIFE LIFE.



5 Reasons to Make You

TRELAN MODEL 23L

1. INNOVATIVE DESIGN

The Trelan Model 23L Whole Tree Chipper has met stringent tests for innovation and progressive design. Added to the time proven features of previous Trelan chippers are new capabilities to provide higher production and larger stem capacities.

The Model 23L features a knuckle boom loader with a lifting capability of 12,500 lbs. at 10 feet. Included on this machine is an all weather operators cab providing the operator with an excellent working view from this vantage point.

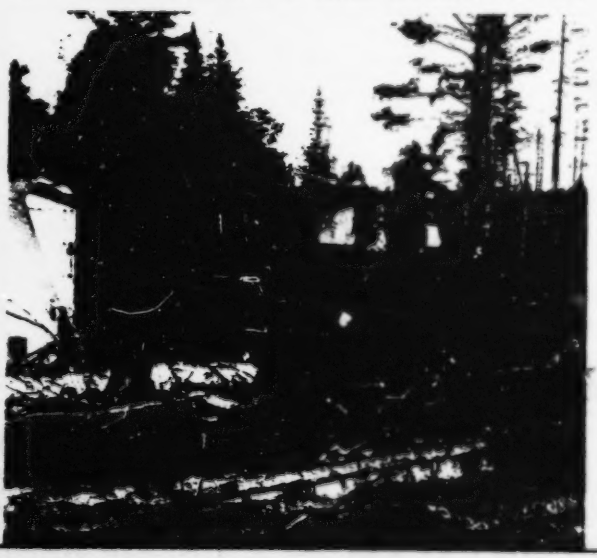
The Trelan Model 23L is especially designed for contractors who require high-production, large-diameter portable chippers which will stand the test of time.

2. EXCEPTIONAL FEATURES

THE MODEL 23L CHIPPER DISC is a patented reduced mass design that requires less torque to accelerate which means faster recovery and less wear on power unit and clutch. Built with three knives 23 inches long to accept 23" diameter roundwood, the Model 23L has an approximate feed rate of 150 ft. per minute. Maximum production can exceed 3 ton per minute.

THE HYDRAULIC INFEED consists of upper and lower feed rolls, synchronized to match the chipper's feed rate. Hydraulic motors with planetaries on the feed rolls produce extra-high torque, and the hydraulic cylinder attached to the upper feed rolls allows down pressure to compress limbs when necessary for better feeding.

THE HORIZONTAL ANVIL reduces concentrated wear spots and allows stems to center on the anvil's mid-range surface for greater torque advantage. More even wear across the entire knife edge is produced, resulting in higher chip quality and longer life for knives, counter knives and anvil.



SEVERAL POWER UNIT OPTIONS are available for the Model 23L. They are DETROIT, CUMMINS, and CATERPILLAR with horsepower ranging from 550 to 750. This enables the owner to customize the Model 23L to best fit their production requirements.

VARIOUS CHIP SIZES are available on the Model 23L and they all produce superior quality uniform chips. A chip separator is also available for even higher quality chips.

3. VALUE TESTED ECONOMY

Minimal maintenance is the by-word of Trelan Chippers. The major components of the Model 23L have been especially selected for durability, to insure long life and low maintenance cost. Because of the Heavy-duty suspension, tires and stabilizers, a horizontal anvil to prevent concentrated wear, and reduced mass chipper disc to lessen power unit strain, the Trelan Whole Tree Chipper is built to last.

4. RESALE VALUE

The resale value of Trelan Chippers has long been applauded by their owners. Because of their ruggedness and customer satisfaction, these machines maintain excellent resale value.

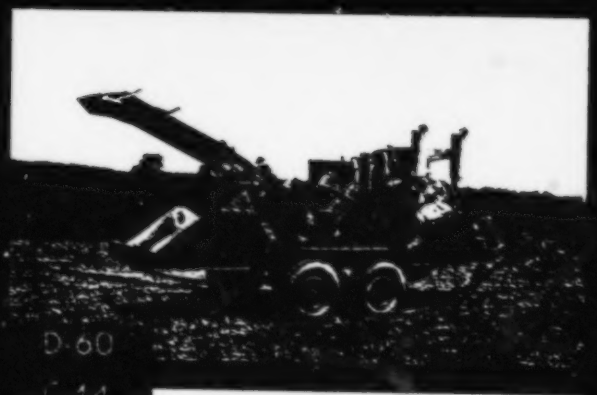
5. ADAPTABLE CAPACITY

Although rated for 23-inch diameter roundwood, the Model 23L was designed to accomodate flared butts and crooked material. The 42-inch diagonal opening at the chipper disc allows stems to twist to accomodate forks and branches, reducing the need for chainsaw cutting. Multiple stems are introduced easily into the 26" x 30" infeed opening for smooth uninterrupted feeding.

Whole Tree Chipper A...

IMPORTANT ADVANTAGES

- Innovative design for maximum chip production.
- Knuckle Boom Loader with Cab
- Low weight for maximum portability
- Heavy-duty suspension, tires and stabilizer
- Reduced mass chipper disc with three full length knives
- Hydraulic powered infeed with planetaries
- Horizontal anvil for less concentrated wear and reduced power requirements
- Good selection of power units
- High production with highest quality uniform chips
- Chip length settings to 1 ½"
- Minimal maintenance through quality manufacturing
- Big 42" diagonal opening at the chipper disc for multiple stems and branches
- Ruggedness for long life and prime resale value
- Fifth wheel hitch
- 440 gallon fuel tank capacity
- 220 gallon hydraulic oil tank with oil cooler
- Hot water heater, windshield wiper and defroster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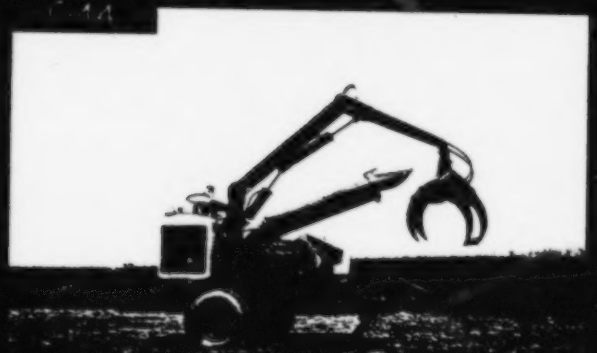
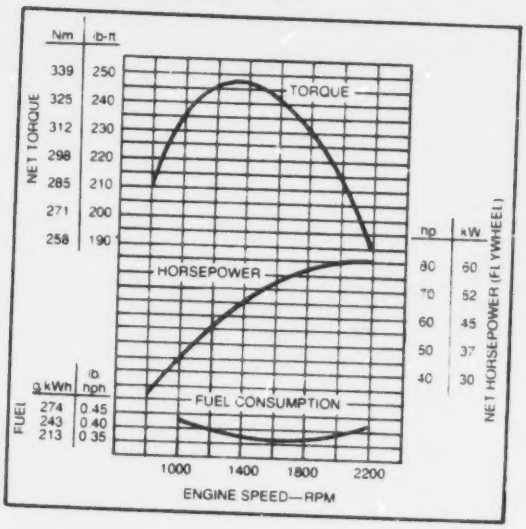


Appendix C

Grapple Skidder Specifications

Model shown may include options

ENGINE PERFORMANCE



FEATURES

80 SAE net hp (60 kW) John Deere turbocharged diesel

Articulated-frame power steering

Automotive-type, position-responsive steering

Oscillating front axle

6-speed Syncro-Range transmission

Front-axle differential lock

Wet-disk power brakes

Wet-disk parking brake

360-degree rotation of grapple

17,600 lb. (7983 kg) maximum lifting capacity

6 ft. 3 in. (1.91 m) grapple opening

Constant grapple pressure during skid

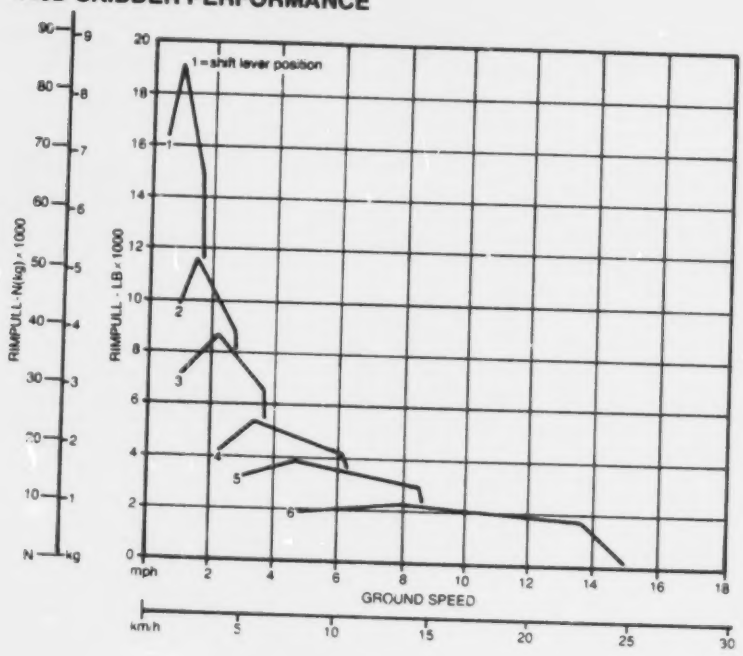
ADD VERSATILITY WITH:

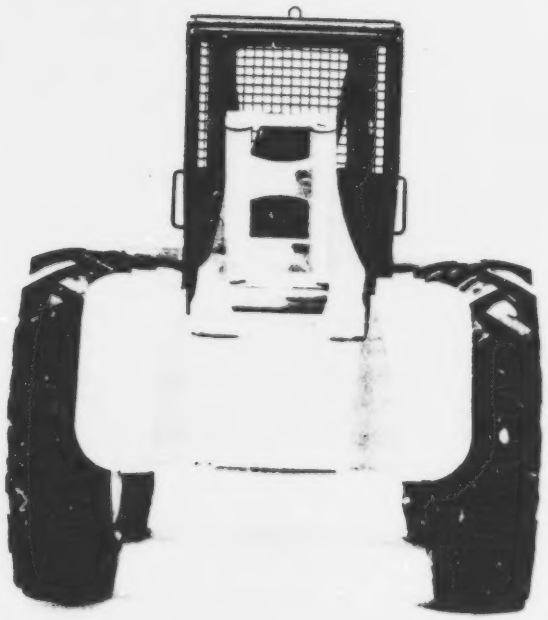
Stacking blade

Extended log bumper

Reversible narrow/wide-gauge wheels and tires

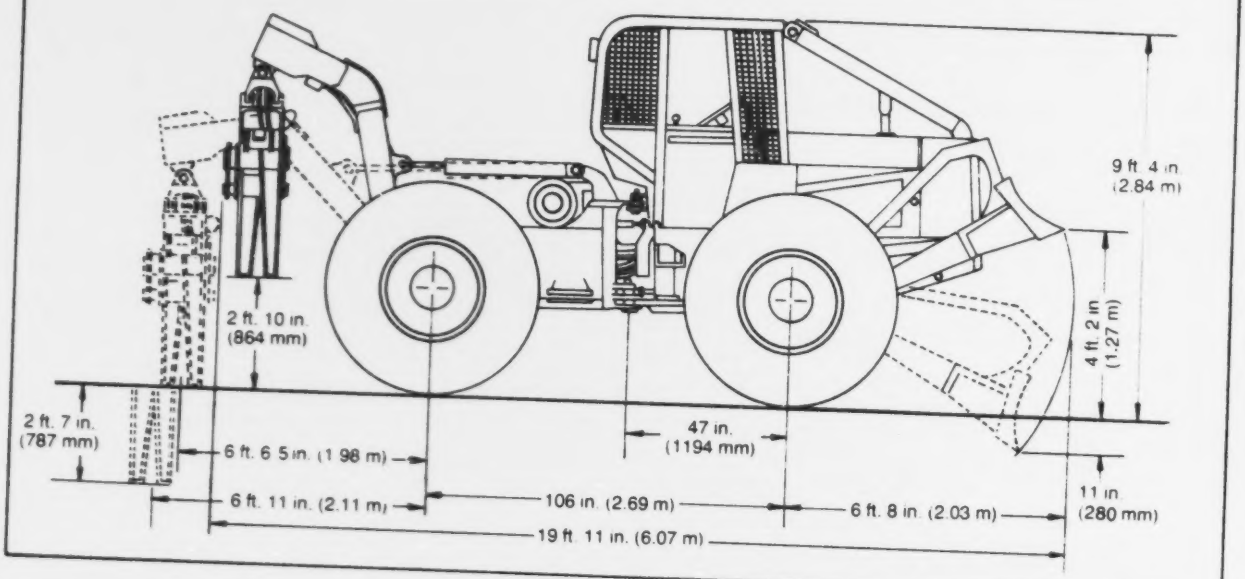
440D SKIDDER PERFORMANCE

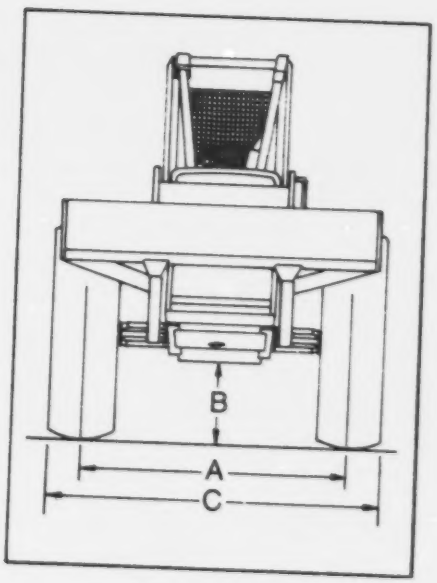




448D GRAPPLE SKIDDER DIMENSIONS

Sideview dimensions are for skidder equipped with 18.4-26 tires, grapple open.





TIRE SIZE AND WHEEL TYPE		A WHEEL TREAD	B GROUND CLEARANCE	C OVERALL WIDTH
16.9-30		76 in. (1.93 m)	19 in. (483 mm)	93 in. (2.36 m)
18.4-26 (Standard wheel and tire)		76 in. (1.93 m)	18 in. (457 mm)	94 in. (2.39 m)
18.4-26 (Narrow-gauge wheel and tire. Type B)		66 in. (1.68 m)	18 in. (457 mm)	85 in. (2.16 m)
18.4-26 (Narrow/wide-gauge wheel and tire. Type A)	Wide-gauge mounting	78 in. (1.98 m)	18 in. (457 mm)	96 in. (2.44 m)
	Reversed narrow-gauge mounting	66 in. (1.68 m)	18 in. (457 m)	85 in. (2.16 m)
18.4-34		76.5 in. (1.94 m)	22 in. (559 mm)	95 in. (2.41 m)
23.1-26		82 in. (2.08 m)	21 in. (533 mm)	106 in. (2.69 m)
28.1-26*		85 in. (2.16 m)	22 in. (559 mm)	114 in. (2.90 m)
68/34-26*		85 in. (2.16 m)	22 in. (553 mm)	117 in. (2.97 m)

*S3 Series special-application axle required.

448D GRAPPLE SKIDDER SPECIFICATIONS

(Specifications and design subject to change without notice. Wherever applicable, specifications are in accordance with ICED and SAE Standards. Except where otherwise noted, these specifications are based on a unit equipped with Syncro-Range transmission, 18.4-26, 10 PR tires, full fuel tank, 175-lb (79 kg) operator and standard equipment.)

Power (@ 2200 engine rpm):	**SAE**	**DIN**
Gross	86 hp (64.1 kW)	
Net	80 hp (60 kW)	60 kW

Net engine power is with standard equipment including air cleaner, exhaust system, alternator and cooling fan. Gross power is without cooling fan. Power ratings are at standard conditions per SAE J1349 and DIN 70 020. No derating is required up to 10,000 feet (3050 m) altitude.

Engine: John Deere turbocharged 4-cylinder-diesel, 4-stroke cycle

Bore and stroke	4.19 × 5.00 in. (106.4 × 127 mm)
Piston displacement	276 cu. in. (4.524 L)
Compression ratio	16.2 to 1
Maximum torque @ 1300 rpm	247 lb-ft (335 Nm) (34.1 kg-m)
Torque rise	29 percent
NACC or AMA (U.S. Tax) horsepower	28
Lubrication	Pressure system w/full-flow filter
Cooling	Pressurized w/thermostat and fixed bypass
Fan	Blower
Air cleaner	Dry-type w/restriction indicator
Electrical system	12-volt w/42-amp alternator
Battery	Reserve capacity: 180 min.

Differentials:

Front and rear axle, with hydraulic-locking differentials.

Transmission: Syncro-Range

Constant-mesh gearing with 6 speeds forward, 3 reverse. Three forward speed ranges with synchronized shifting between low and high within each range. Clutch is 12 inches (305 mm), dry, feramic-faced, pedal-operated.

Travel Speeds: (2200 engine rpm, no tire slip):

	mph	**km/h**
Forward	1.7-14.1	2.7-22.7
Reverse	1.7-8.5	2.7-13.7

Drive Axles:

Four-wheel drive with S3 Series axles. Inboard planetaries on all axles. Front axle oscillates 15 degrees above and below horizontal. Travel at tire center line 20 in. (508 mm).

Steering:

Hinged-frame power steering. Position-responsive steering actuated by dual double-acting cylinders. Steering system has hydraulic-pressure priority.

Outside clearance circle w/o blade	33 ft. 10 in. (10.3 m)
Outside clearance circle w/blade	34 ft. 10 in. (10.6 m)
Steering wheel rotation, max. left to right	3 turns

Brakes:

Service: Hydraulic power, foot-actuated, enclosed wet-disk service brake for front and rear. Located on transmission output shaft.

Parking, winching and emergency stop: Hand-operated mechanical wet-disk brake located on driveline for braking front and rear axles. Hydraulic release.

Hydraulic System:

Closed center, constant pressure. Variable-displacement pump drive from engine crankshaft: 25 gpm (1.58 L/s), 2000 psi (13 790 kPa) (140.6 kg/cm²) @ 2200 engine rpm.

Full-flow filtration, 10-micron filter, oil-to-air cooler. Charge pump driven from winch drive.

Hydraulic Cylinders	**Bore**	**Stroke**
Blade lift cylinders (2)	3.50 in. (89 mm)	14.25 in. (362 mm)
Steering cylinders (2)	2.75 in. (70 mm)	14.37 in. (365 mm)
Grapple boom cylinders (2)	4.0 in. (102 mm)	29.8 in. (757 mm)
Grapple tong cylinders (1)	5.25 in. (133 mm)	16.8 in. (427 mm)
Blade lift rod (2) dia.	1.50 in. (38.1 mm)	
Steering cylinder rod (2) dia.	1.75 in. (45 mm)	
Grapple boom rod (2) dia.	2 in. (51 mm)	
Grapple tong rod (1) dia.	2.25 in. (57 mm)	

Cylinder rods are ground, heat-treated, chrome-plated, polished.

Tires:

16.9-30, 10 PR, steel, LS2, logger
18.4-26, 10 PR, steel, LS2, logger
18.4-26, 10 PR, LS2, logger
18.4-34, 10 PR, steel, LS2, logger
18.4-34, 16 PR, synthetic, LS2, logger
23.1-26, 10 PR, steel, LS2, logger
23.1-26, 16 PR, synthetic, LS2, logger
28.1-26, 10 PR, steel, LS2, logger
68/34-26, 16 PR, synthetic, LS2, logger, tubeless

Capacities:	**U.S.**	**Liters**
Fuel tank	41 gal.	155.2
Cooling system	8 gal.	30.3
Engine lubrication, w/filter	15 qt.	14.2
Transmission and hydraulic system	8 gal.	30.3
Front differential	4.5 gal.	17
Rear differential	4.5 gal.	17
Winch	2.5 gal.	9.5

Blade: Hydraulic control

Width	6 ft. 11 in. (2.11 m)
Max. lift above ground level	4 ft. (1.22 m)
Max. drop below ground level	9.5 in. (241 mm)

Winch:

Live mechanical drive; hydraulically actuated clutch and brake. Single lever control.

Winch capacities:*

½ in. (12.7 mm) cable	223 ft. (68 m)
⅝ in. (15.8 mm) cable	146 ft. (44.5 m)
¾ in. (19.1 mm) cable	103 ft. (31.4 m)

*Calculated—no allowance made for loose or uneven spooling

Linepull:**

Bare drum	26,660 lb. (118.6 kN) (12 093 kg)
Full drum	18,129 lb. (80.6 kN) (8223 kg)

**Based on maximum engine torque.

Line speed (2200 rpm):

Bare drum	131 fpm (40 m/min)
Full drum	187 fpm (57 m/min)

Log Grapple:

Grapple boom: Pin-mounted, A-frame, welded box construction. Integral light mounts. Internally protected hydraulic lines.

Grapple and tongs: Gear-driven, with 360-degree continuous rotation. Tapered roller bearings on rotation shaft. Mechanically linked tongs.

Tongs:

Tip closure force	6300 lb. (28 kN) (2858 kg)
Lift force	17,600 lb. (78 kN) (7983 kg)
Enclosure area, tong tips meeting	8 sq. ft. (0.74 m²)
Tong tips open to	75 in. (191 cm)
Tongs close to log dia.	5 in. (12.7 cm)

SAE Operating Weight w/Blade	16,886 lb. (7659 kg)
SAE Operating Weight w/o Blade	16,046 lb. (7278 kg)
SAE Operating Weight w/o Winch	16,066 lb. (7287 kg)
SAE Operating Weight w/o Blade and Winch	15,226 lb. (6906 kg)

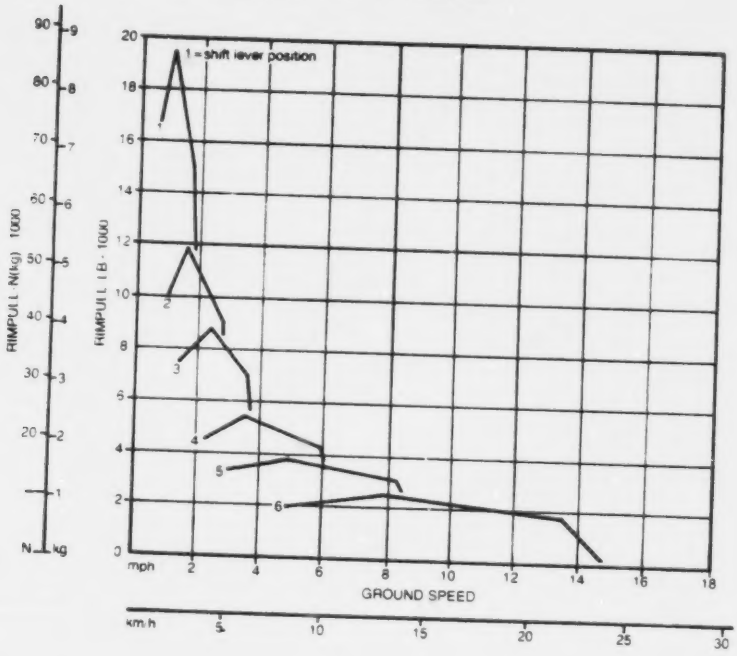
Additional Standard Equipment:

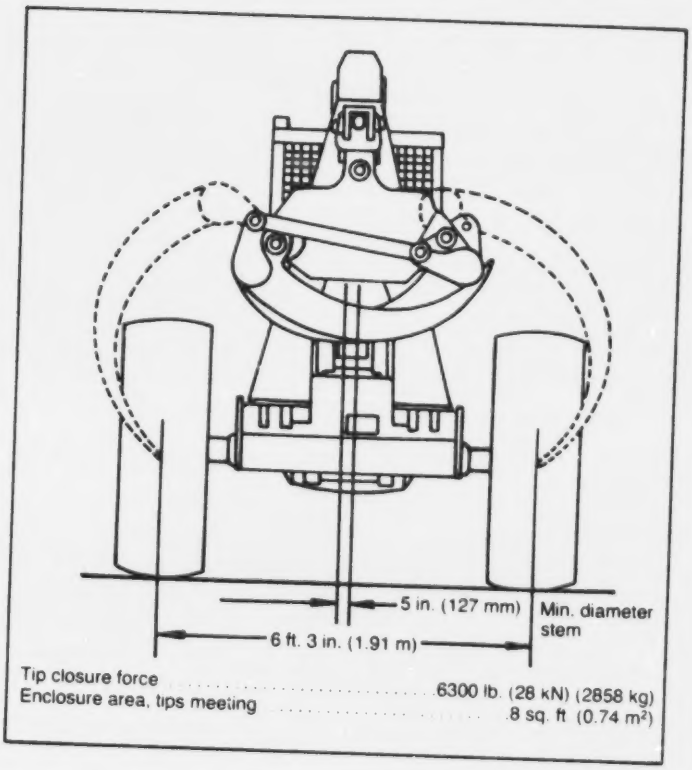
Alternator warning light
Bottom guards, full length
Canopy (ROPS), brush screens, limb risers
Cushion seat w/suspension position adjustment and seat belt
Engine oil pressure warning light
Engine sideshields
Exhaust w/rain deflector
Foot throttle
Full steering wheel
Gauges:
  Electric hourmeter
  Engine coolant temperature
  Fuel level
Heavy-duty starter
Hinge locking bar
Horn
Key switch w/pushbutton safety start
Log grapple
Muffler
Parking brake warning light
Vandal protection for radiator filler cap
Winch

Optional or Special Equipment:

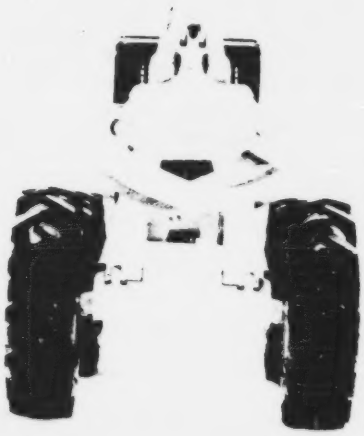
Cab (ROPS) w/noise treatment, windshield washer and wiper, limb risers
Canopy and grapple lights
Canopy (ROPS), windows, door, brush screens, limb risers
Cold-weather starting package:
  Batteries (2), 420-min. reserve capacity
  Ether starting aid, electric
  Hand speed control
Engine coolant heater
Fairlead on grapple boom for winch
Fire extinguisher
Grapple log bumpers
Hand throttle
Secondary steering system (requires two AR105227 accumulators)
Stacking blade
3-in. (76 mm) seat belt
Vandal protection for instrument panel and fuel tank
Winch warm-up kit

448D GRAPPLE SKIDDER PERFORMANCE





Tip closure force ..... 6300 lb. (28 kN) (2858 kg)
Enclosure area, tips meeting ..... .8 sq. ft (0.74 m²)



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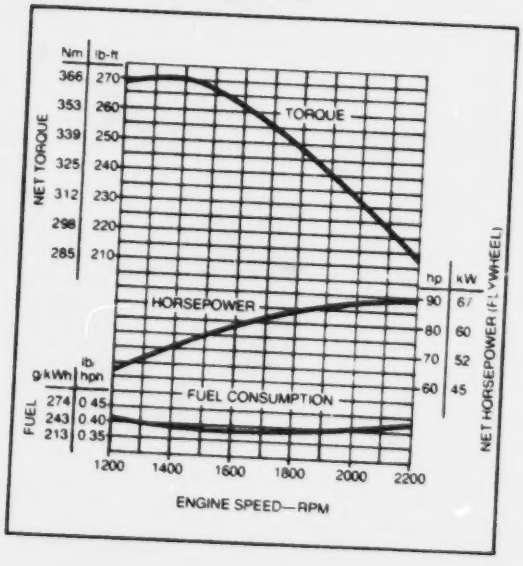
ENGINE PERFORMANCE



FEATURES

90 SAE net hp (67 kW)

Articulated frame steering

Automotive-type, position responsive steering

Oscillating front axle

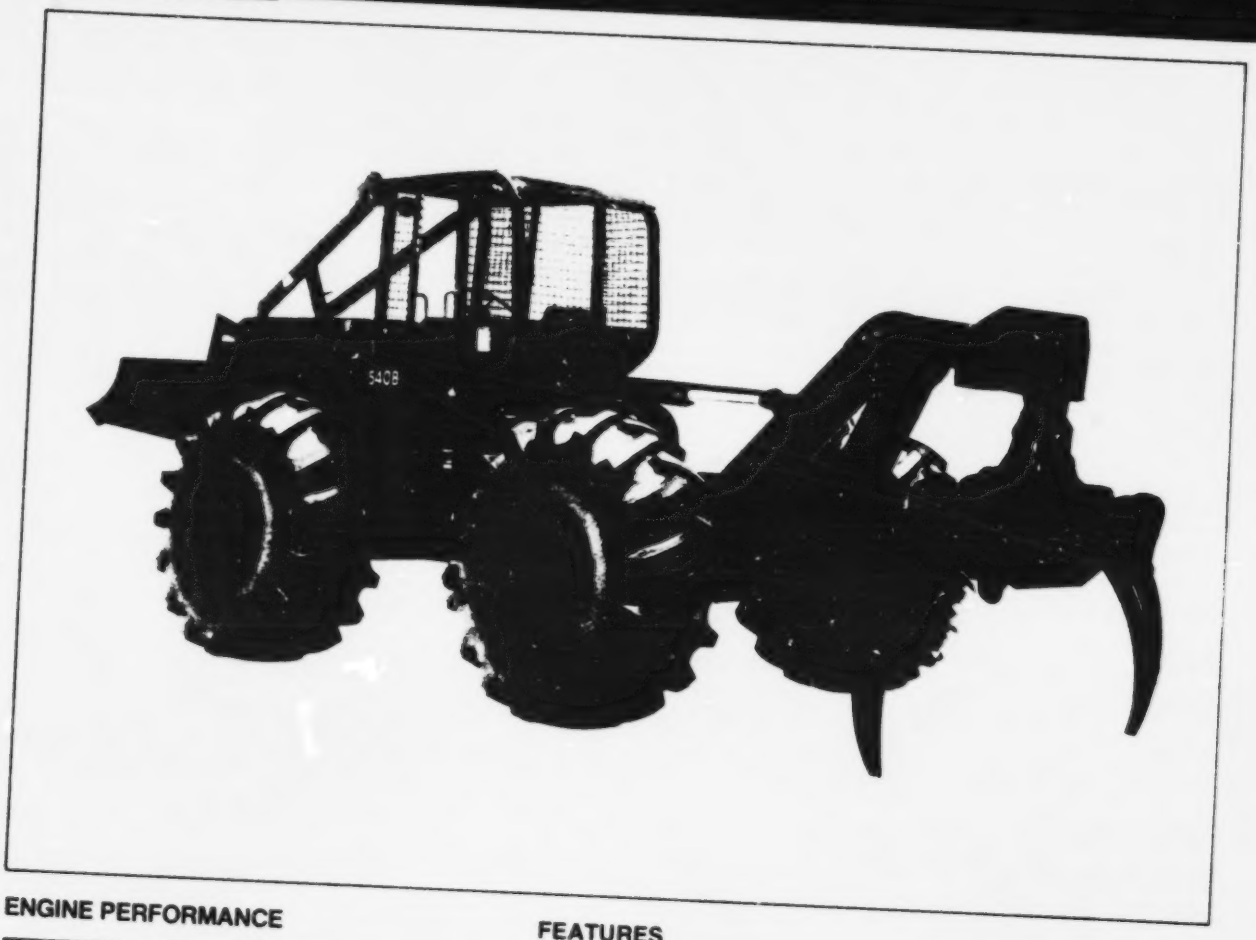
Power Shift transmission

Differential lock on both axles

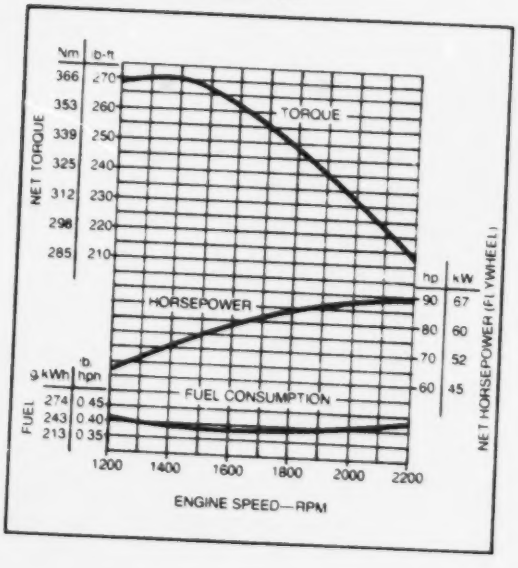
4-wheel, wet-disk power brakes never need adjusting

Hydraulically controlled winch

Adjustable arch rollers



ENGINE PERFORMANCE



FEATURES

90 SAE net hp (67 kW)

Articulated frame steering

Automotive-type, position responsive steering

Oscillating front axle

Power Shift transmission

Differential lock on both axles

4-wheel, wet-disk power brakes never need adjusting

360-degree rotation of grapple

20,700 lb. (9390 kg) maximum lifting capacity

6 ft. 3 in. (1.91 m) grapple opening

Constant grapple pressure during skid

540B GRAPPLE SKIDDER SPECIFICATIONS

(Specifications and design subject to change without notice. Wherever applicable, specifications are in accordance with ICED and SAE Standards. Except where otherwise noted, these specifications are based on a unit equipped with 23.1-26, 10-PR tires, full fuel tank, 175-lb. (79 kg) operator and standard equipment.)

Power (@ 2200 engine rpm):	**SAE**	**DIN**
Gross	96 hp (71.5 kW)	
Net	90 hp (67 kW)	67 kW

Net engine power is with standard equipment including air cleaner, exhaust system, alternator and cooling fan. Gross power is without cooling fan. Power ratings are at standard conditions per SAE J1349 and DIN 70 020. No derating is required up to 10,000 feet (3050 m) altitude.

Engine: John Deere turbocharged diesel, 4-cylinder, 4-stroke cycle

Bore and stroke	4.19×5 in. (106×127 mm)
Piston displacement	276 cu. in. (4.524 L)
Compression ratio	16.2 to 1
Maximum torque @ 1400 rpm	270 lb-ft (366 Nm) (37.32 kg-m)
NACC or AMA (U.S. Tax) horsepower	28
Lubrication	Pressure system w/full-flow filter
Cooling	Pressurized w/thermostat and fixed bypass
Fan	Blower
Air cleaner w/restriction indicator	Dry
Electrical system	12-volt w/alternator
Batteries (2)	Reserve capacity: 340 minutes

Differentials:
Front and rear ..... Full differentials w/hydraulic lock

Engine Clutch Disconnect:
Hand-operated, spring-loaded, dry-disk. Single plate, 12 in. (305 mm).

Transmission:
Power Shift with planetary gears, hydraulically actuated wet-disk clutches and brakes; provides 8 speeds forward—4 reverse. Controlled by single lever on console.

Travel Speeds (2200 engine rpm, no tire slip):
Forward: 1.7 to 17.9 mph (2.7 to 28.8 km/h)
Reverse: 2.0 to 5.8 mph (3.2 to 9.3 km/h)

Drive Axles:
Four-wheel drive with inboard planetary gears on all axles. Front axle oscillates 15 degrees above and below horizontal. 20 in. (508 mm) total travel at tire center line.

Brakes:
Hydraulic power actuated, dual controlled disks on 4 wheels, lockable for winching. Hand-operated mechanical brake for parking and emergency stop.

Power Steering:
Articulated frame hydraulically actuated by dual cylinders. Steering system has hydraulic pressure priority.

Turning radius	16 ft. 4 in. (4.98 m)
Turning clearance	34 ft. 5 in. (10.49 m)

Hydraulic System:
Closed-center constant pressure. Variable-displacement pump driven from crankshaft ..... 25 gpm (1.58 L/s) 2000 psi (13 790 kPa) (140.6 kg/cm²) @ 2200 engine rpm. Full flow filtration. Oil-to-air cooler.

Hydraulic Cylinders:	**Bore**	**Stroke**
Lift (2)	4.0 in. (102 mm)	30 in. (762 mm)
Grapple (1)	5.25 in. (133 mm)	17 in. (432 mm)
Cylinder rods	2-in. (51 mm) dia.	
Grapple cylinder rod	2.25 in. (57 mm) dia.	

Tires:
18.4-34, 10-PR, steel-ply, LS2
18.4-34, 16-PR, Kevlar, LS2
23.1-26, 10-PR, steel-ply, LS2
23.1-26, 16-PR, Kevlar, LS2
28.1-26, 10-PR, steel-ply, LS3
68/34-26, 16-PR, Kevlar tubeless, LS2

Capacities:	**U.S.**	**Liters**
Fuel tank	42 gal.	159
Cooling system	8 gal.	30.3
Engine lubrication, including filter	15 qt.	14.2
Transmission and hydraulic system	9 gal.	34.1
Front differential	4.5 gal.	17
Rear differential	4.5 gal.	17
Winch	2.5 gal.	9.5

Additional Standard Equipment:
Alternator warning light
Bottom guards
Canopy w/ROPS, brush screens and limb risers
Cigaret lighter
Cushion seat w/suspension, position adjustment and seat belt
Engine side shields
Ether starting aid
Exhaust w/rain deflector
Fire extinguisher
Gauges:
- Electric hourmeter
- Engine coolant temperature
- Engine oil pressure
- Fuel
- Transmission oil temperature

Hand and foot throttle
Heavy-duty starter
Hinge locking bar
Horn
Key switch w/pushbutton safety start
Muffler
Parking brake w/warning light and buzzer
Stacking blade
Transmission oil pressure warning light
Solid-state voltage regulator
Vandal protection
Winch

SAE Operating Weight ..... 18,675 lb. (8470 kg)

Winch:
Cable capacities*:

½-in. (12.7 mm) cable	223 ft. (68 m)
⅝-in. (15.8 mm) cable	146 ft. (45 m)
¾-in. (19.1 mm) cable	103 ft. (31.4 m)

*Calculated. No allowance made for loose or uneven spooling.

Linepull**:

Bare drum	30,599 lb. (136.1 kN) (13 879 kg)
Full drum	20,807 lb. (93 kN) (9438 kg)

**Based on maximum engine torque.

Line speed (2200 rpm):

Bare drum	125 fpm (38 m/min)
Full drum	179 fpm (55 m/min)

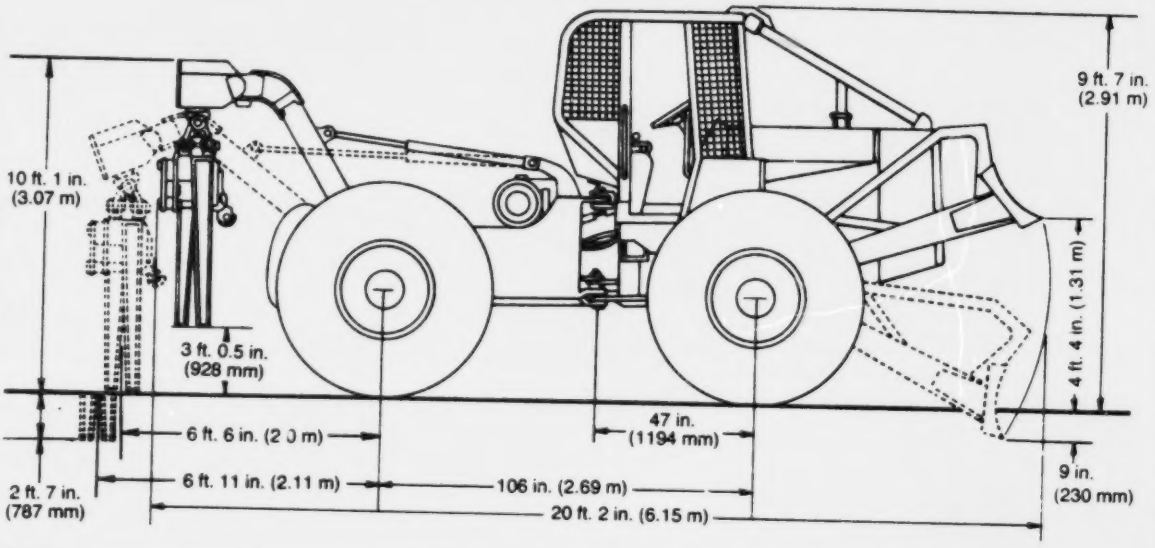
Blade: Hydraulic control

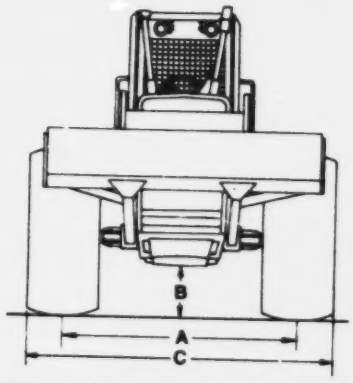
Width	6 ft. 11 in. (2.11 m)
Height (ends)	1 ft. 8 in. (508 mm)
Height (center)	2 ft. 3 in. (686 mm)
Max. lift above ground level	4 ft. 4 in. (1.31 m)
Max. drop below ground level	9 in. (229 mm)

Special Equipment:
3-in. (76 mm) seat belt
Cab w/ROPS, heater, noise treatment and wiper
Canopy w/ROPS, screened doors, right window, windshield and wiper
Lights (field only)
Engine coolant heater
Fairlead for winch
Steering accumulator
Wheel weights

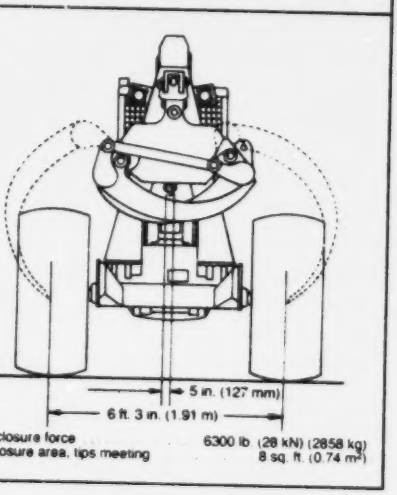
540B GRAPPLE SKIDDER DIMENSIONS

Sideview dimensions are for skidder equipped with 23.1-26 tires, grapple open.

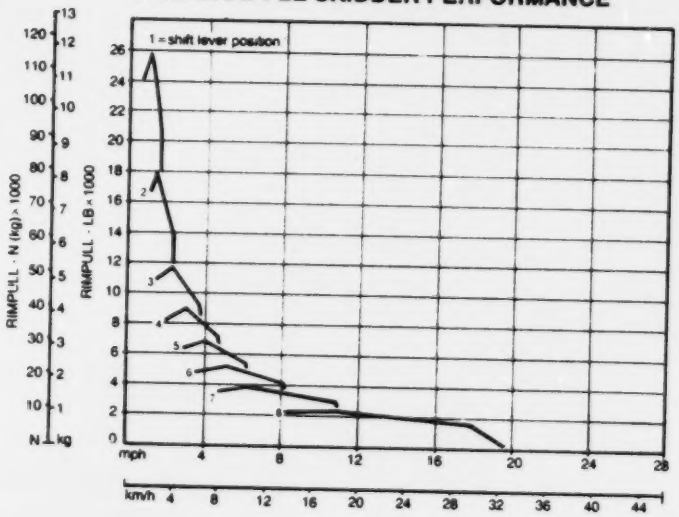




TIRE SIZE	A WHEEL TREAD	B GROUND CLEARANCE	C OVERALL WIDTH
18.4-34	76.5 in. (1.94 m)	1 ft. 10 in. (559 mm)	7 ft. 11.1 in. (2.42 m)
23.1-26	80.8 in. (2.05 m)	1 ft. 9 in. (533 mm)	8 ft. 8.6 in. (2.66 m)
28.1-26	85.4 in. (2.17 m)	1 ft. 9.5 in. (546 mm)	9 ft. 5.5 in. (2.88 m)
68/34-26	85.4 in. (2.17 m)	1 ft. 10.3 in. (566 mm)	9 ft. 9 in. (2.97 m)



540B GRAPPLE SKIDDER PERFORMANCE



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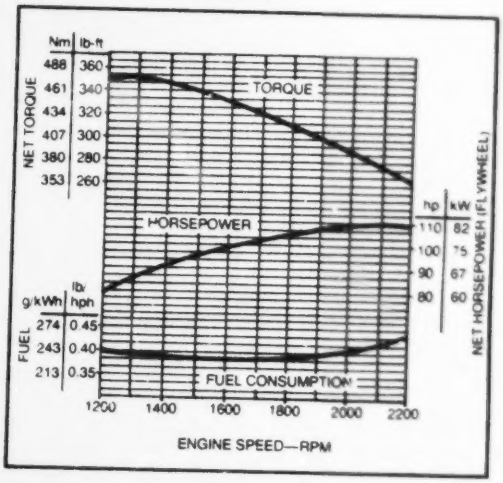
ENGINE PERFORMANCE



FEATURES

110 SAE net hp (82 kW)

Articulated frame steering

Automotive-type, position-responsive steering

Oscillating front axle

Power Shift transmission

Differential lock on both axles

4-wheel, self-adjusting, wet-disk power brakes

Hydraulically controlled winch

Stacking blade

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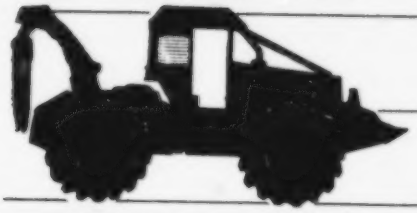
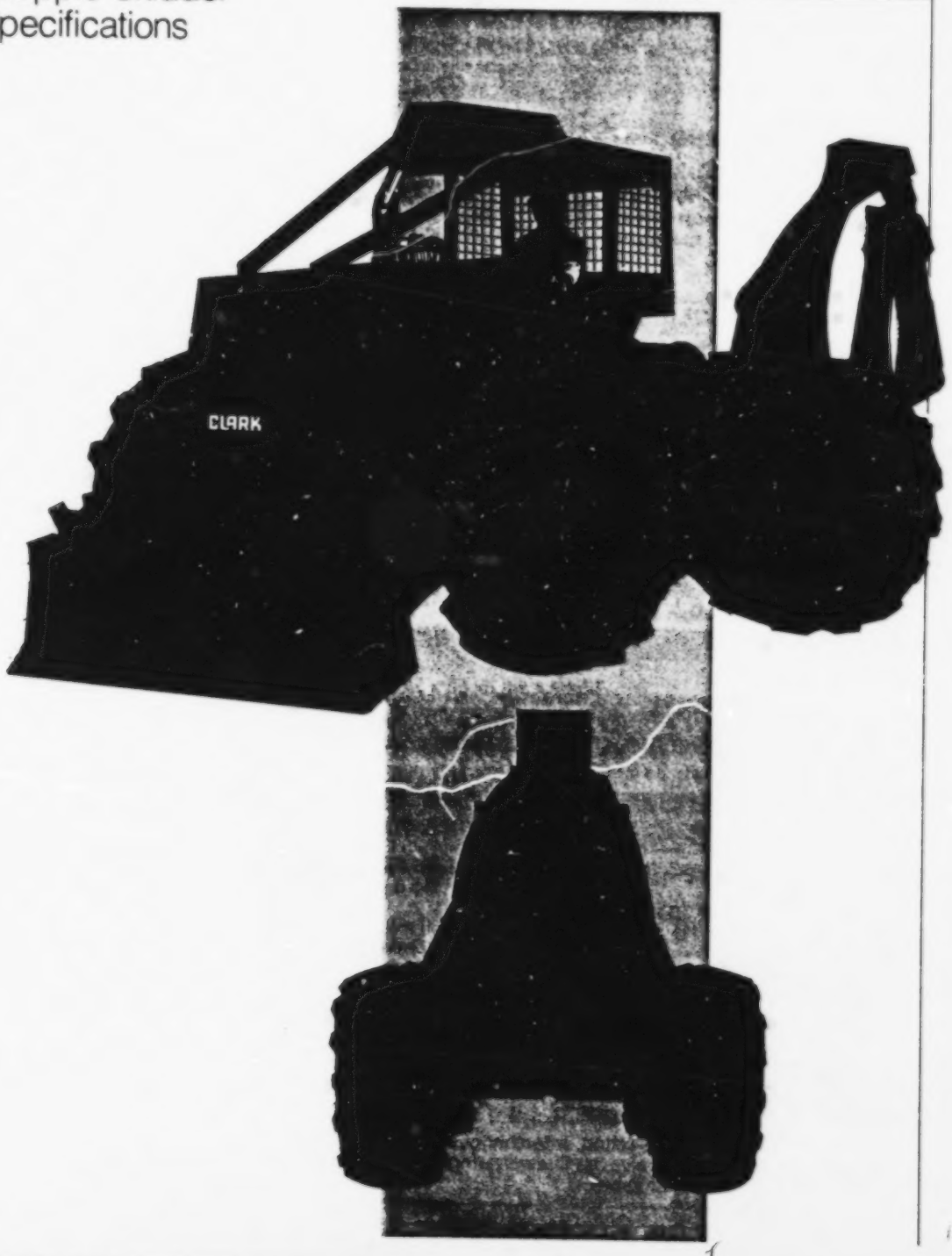
CLARK 665D



Grapple Skidder
Specifications



ENGINE (Turbocharged)

Make	Detroit Diesel
Model	3-53T
Maximum hp (kW)*	125 (93)
Flywheel hp (kW)**	116 (86,5)
Governed rpm	2500
Maximum torque, lbf • ft	302 @ 1600
N • m	409 @ 1600
Bore and stroke, in	3.88 x 4.50
mm	98,6 x 114,3
Number of cylinders	3
Displacement, in³ (L)	159 (2,6)
Fuel tank capacity, U.S. gal (L)	40 (151,0)
Electrical system (alternator)	12V, 42A

*Max. hp of basic engine; SAE J816 standard ambient conditions.

**Net usable hp at engine flywheel at 500 ft (152,4 m) altitude & 85°F (29.5°C) ambient conditions with fan, alternator, water pump, lube oil pump, fuel pump, and air cleaner.

DRIVETRAIN

TORQUE CONVERTER: Clark industrial type; 2.29 to 1 multiplication factor.

TRANSMISSION: Clark countershaft type powershift, three speeds forward, three speeds reverse. Travel speeds:*

mph	3.9	7.5	17.0
km/h	6,3	12,1	27,4

*Measured with 23.1-26, 16PR tires.

AXLES: Clark with low-friction roller bearing planetary in each wheel. Single-piece cast steel housing with bolt-on spindles; front and rear NoSpin differentials. Front axle oscillates a total of 28°, rear axle fixed.

BRAKES

SERVICE: Clark hydraulically actuated, multiple disc, oil cooled; fully enclosed on rear of transmission.

PARKING: Manually actuated lock on service brake.

TIRES (Nylon Logger Compound)

Standard	23.1-26, 16PR
Optional*	18.4-34, 18.4-26, 28.1-26, 24.5-32, 67 x 34-25, 68 x 34-32

*Tires with steel guard construction also available.

HYDRAULIC SYSTEM

PUMP: Gear type; flywheel driven by splined shaft through torque converter; 23.8 U.S. gpm (90,1 L/min) capacity at 2000 rpm.

System capacity	15.6 U.S. gal	(59,0 L)
Reservoir capacity	14.75 U.S. gal	(55,8 L)

CYLINDERS: Double acting

Blade lift (1), Steering (1)	4.0 in dia.	(101,6 mm)
Arch (2), Grapple (2)	4.0 in dia.	(101,6 mm)

HYDRAULIC VALVES: (2); one for steering and blade; second for arch and grapple; both with adjustable main relief valve.

STEERING SYSTEM

Articulated frame; full hydraulic power steering, lever-type control.

CYLINDER: One (1), double-acting, interchangeable with blade lift cylinder. Steering valve has fine metering and two (2) separate overload relief valves.

WINCH (Clark WD-200)

Maximum linepull (bare drum), lbf (kN)*	23 600	(105,0)
Maximum line speed (bare drum), fpm (m/min)*	418	(127,4)

Winch drum 9 in (228,6 mm) dia. x 9 in (228,6 mm) width; 16 in (406,4 mm) flange dia. with breakaway anchor.

Rated capacity, lbf (kN)	24 000	(106,8)

Mechanically driven "live" shaft; torque converter automatically adjusts power/speed for linepull up to maximum without shifting gears while standing or moving. Hydraulically controlled; winch prop shaft does not rotate unless winch drive clutch engaged. Sealed winch housing has self-contained lubricating oil supply; self-adjusting for wear with external adjustment for freespool drag.

*Based on 85% efficiency with 0.50 in (12,7 mm) dia. rope.

DRUM CAPACITY (Wire Rope)

0.50 in dia. – 396 ft	(12,7 mm dia. – 120,7 m)
0.63 in dia. – 276 ft	(16,0 mm dia. – 84,1 m)
0.75 in dia. – 192 ft	(19,1 mm dia. – 58,5 m)

WEIGHT (Approx. Shipping)

Front axle, lb (kg)	9650	(4377)
Rear axle, lb (kg)	9950	(4513)
Total, lb (kg)	19 600	(8890)

STANDARD EQUIPMENT

Adjustable bucket seat
Seat belt (SAE J386)
Neutral start switch
Electrical disconnect switch and main circuit breaker
Full engine compartment side panels
Twin 5 lb (2,3 kg) fire extinguishers
ROPS (SAE J1040) and FOPS (SAE J231) canopy
Quick connect pressure check ports
Wrap-around rear fenders
Full-length keel-shaped belly guards
Steering frame lock (SAE J276)
INSTRUMENTS/GAUGES
Engine oil pressure
Engine coolant temperature
Torque converter temperature
WARNING LIGHT
Parking brake
FILTERS
Engine oil
Air (2 stage dry, with service indicator and safety element)
Hydraulic oil (full flow 10 micron return)
Transmission/torque converter
Pusher fan
Muffler
Utility blade
Ammeter
Hourmeter
Fuel

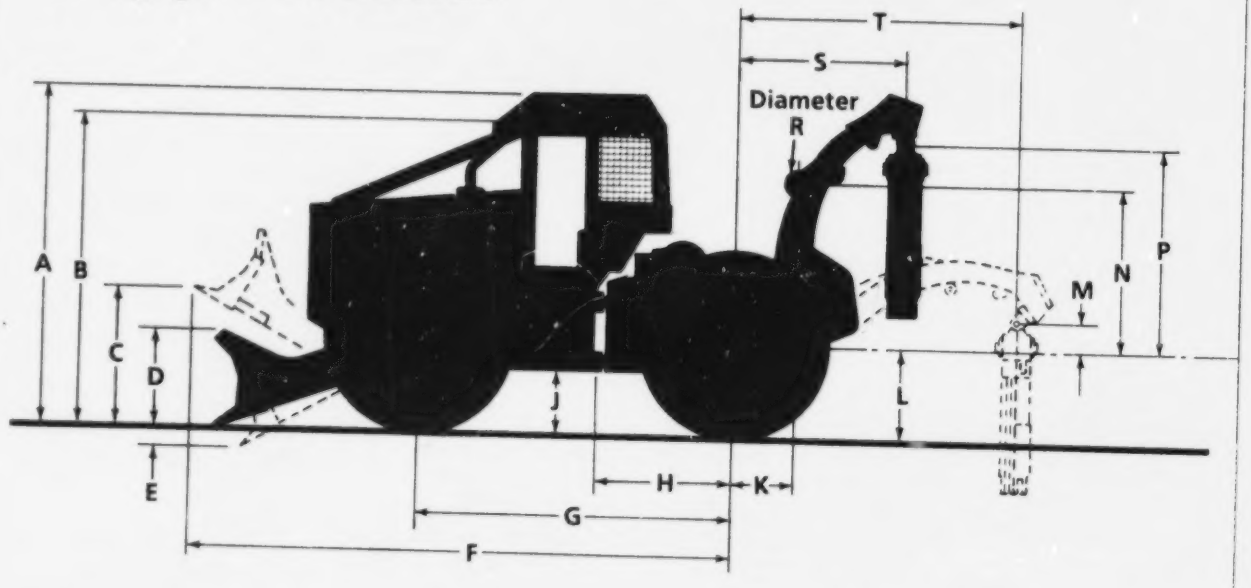
OPTIONAL EQUIPMENT

Windshield (Lexan)
Engine air precleaner
Engine block heater
Engine oil drain (remote)
Secondary brake (SAE J1178)
Cab mesh doors
Cab heater/defroster
Dual battery kit
Heavy-duty alternator, 60A
See-through arch grille
Engine compartment side panels (solid)
OPS (SAE J1084) kit includes mesh screen doors and front screen
OPS (SAE J1084) cold weather enclosure kit includes Lexan brush guard windows, safety glass side and rear windows.
Washer
Suction fan
Hand throttle
Blade extensions
Fender extensions
Front tow hook
Cable cutter
Wiper
Work light kit
Fairlead 4th roller

MACHINE DIMENSIONS

Clearance Circle, in (m) 413.5 (10,5)
Width Over Tires, in (mm) 108.75 (2762)
Track, Front & Rear, in (mm) 83.75 (2127)
Blade Width, in (mm) 84.0 (2134)

665D
Grapple Skidder

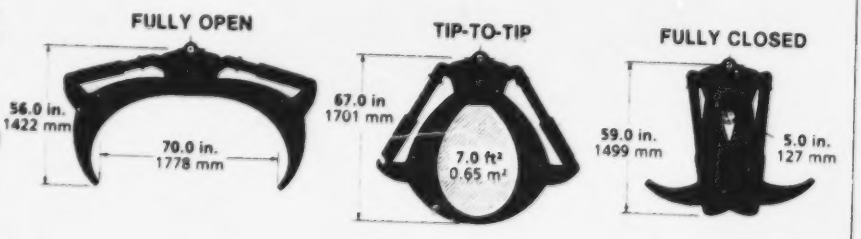


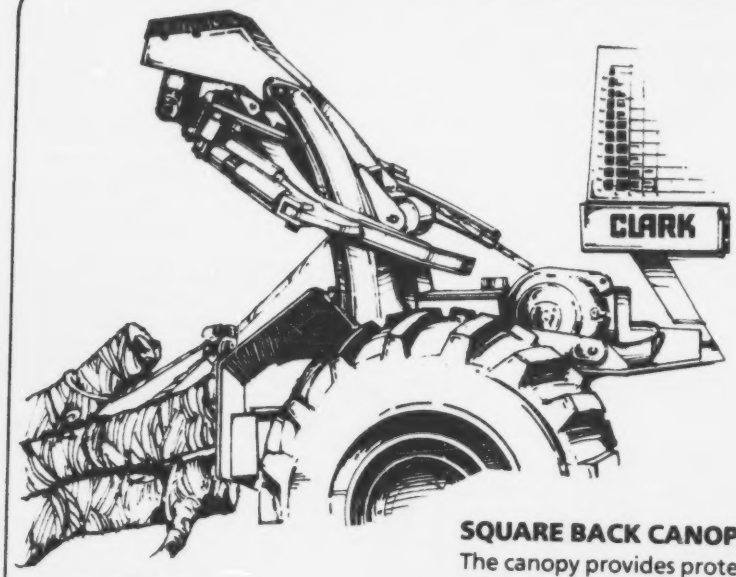
TIRES		A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T
18.4-26	in	112.0	102.8	43.0	31.5	11.4	178.5	110.0	45.0	16.6	15.6	26.0	9.0	47.2	66.0	9.0	55.0	93.0
	mm	2845	2611	1092	800	290	4534	2794	1143	422	396	660	229	1199	1676	229	1397	2362
18.4-34	in	116.0	106.8	47.0	31.5	7.4	178.5	110.0	45.0	20.6	15.6	30.0	9.0	47.2	66.0	9.0	55.0	93.0
	mm	2946	2713	1194	800	188	4534	2794	1143	523	396	762	229	1199	1676	229	1397	2362
23.1-26	in	115.0	105.8	46.0	31.5	8.4	178.5	110.0	45.0	19.6	15.6	29.0	9.0	47.2	66.0	9.0	55.0	93.0
STD	mm	2921	2687	1168	800	213	4534	2794	1143	498	396	737	229	1199	1676	229	1397	2362
24.5-32	in	118.4	109.2	49.4	31.5	5.0	178.5	110.0	45.0	23.0	15.6	32.4	9.0	47.2	66.0	9.0	55.0	93.0
	mm	3007	2774	1255	800	127	4534	2794	1143	584	396	823	229	1199	1676	229	1397	2362
28.1-26	in	116.0	106.8	47.0	31.5	7.4	178.5	110.0	45.0	20.6	15.6	30.0	9.0	47.2	66.0	9.0	55.0	93.0
	mm	2946	2713	1194	800	178	4534	2794	1143	523	396	762	229	1199	1676	229	1397	2362
67 x 34-25	in	116.4	107.2	47.4	31.5	7.0	178.5	110.0	45.0	21.0	15.6	30.4	9.0	47.2	66.0	9.0	55.0	93.0
	mm	2957	2723	1204	800	178	4534	2794	1143	533	396	772	229	1199	1676	229	1397	2362
68 x 34-32	in	116.7	107.5	47.7	31.5	6.7	178.5	110.0	45.0	21.3	15.6	30.7	9.0	47.2	66.0	9.0	55.0	93.0
	mm	2964	2731	1212	800	170	4534	2794	1143	541	396	780	229	1199	1676	229	1397	2362

GRAPPLE

Grapple Head: Reversible hydraulic motor with chain reducer and friction disc snubber; head is capable of continuous, bi-directional rotation.

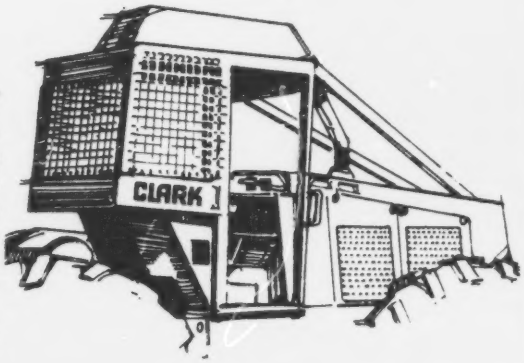
Arch: Tubular construction; mounted on rear frame with 1.75 in (44,5 mm) dia. pins in spherical bushing. Integral fairlead, two side rollers 4.0 in (101,6 mm), main roller, 8.5 in (215,9 mm) diameter.





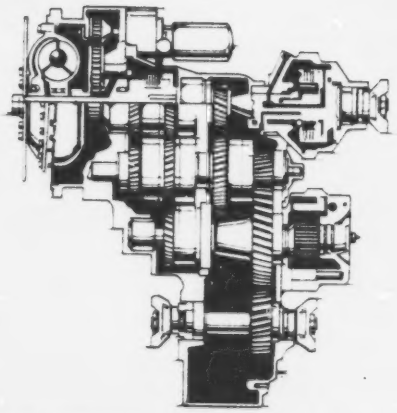
SWING-UP GRAPPLE

The 665D can convert easily from a grapple skidder to a cable skidder. The operator merely swings and pins the grapple up and out of the way. The arch has built-in fairlead rollers, and the WD-200 winch is ready for efficient cable skidding.



SQUARE BACK CANOPY

The canopy provides protection, plenty of elbow room and excellent all-around outward vision. Wire mesh side panels plus side brush guards keep brush and overhanging branches from hitting the operator. Kits meeting OPS requirements may be fitted to the canopy; see Optional Equipment.

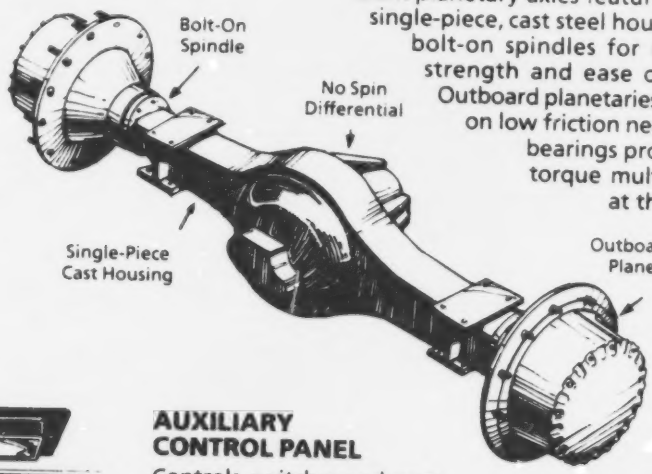


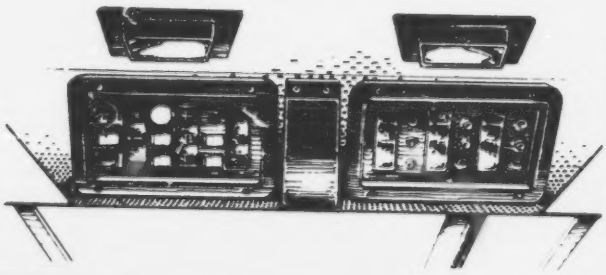
TRANSMISSION

The Clark powershift transmission with integral torque converter offers three forward and reverse speeds. The compact countershaft design incorporates an oil-cooled multi-disc service/parking brake system and a winch drive clutch.

PLANETARY AXLES

Clark planetary axles feature durable, single-piece, cast steel housings with bolt-on spindles for maximum strength and ease of service. Outboard planetaries mounted on low friction needle roller bearings provide final torque multiplication at the wheels.





AUXILIARY CONTROL PANEL

Controls, switches and reset-type circuit breakers for optional equipment including work lights, windshield washer and wiper plus the cab heater/defroster are located in a recessed ceiling panel. Switches and controls are utilized in conjunction with cab enclosure kits; see Optional Equipment.

CLARK Construction Machinery Division

Specifications subject to change without notice or obligation.
Illustrations used in this publication may include optional equipment.

GS665D NOV 82 Printed in U.S.A.

Appendix D

Specifications of Feller-Buncher Prime Movers and Shears

CATERPILLAR

Machine shown may have optional equipment.

Caterpillar Engine

Flywheel power @ 2400 RPM — 65 HP/48 kW

(Kilowatts (kW) is the International System of Units equivalent of horsepower.)

The net power at the flywheel of the vehicle engine operating under SAE standard ambient temperature and barometric conditions, 85° F/29° C and 29.38" Hg/99.5 kPa, using 35 API gravity fuel oil at 60° F/15.6° C and after deductions for fan, air cleaner, water pump, lubricating oil pump, fuel pump, muffler and alternator. Engine will maintain specified flywheel power up to 7500 feet/2300 m altitude.

Caterpillar 4-stroke-cycle 3204 diesel Engine with four cylinders, 4.5"/114 mm bore, 5"/127 mm stroke and 318 cu. in./5.2 liters displacement.

Direct injection Caterpillar fuel system with individual adjustment-free injection pumps and valves.

AEHQ9469

910
Wheel Loader

engine (continued)

Cam-ground and tapered aluminum alloy pistons with 2-ring design. Steel-backed aluminum bearings. Hardened crankshaft journals. Pressure lubrication with full-flow filtered and cooled oil. Dry-type air cleaner with primary and safety elements.

12-volt direct electric starting system with 40-amp alternator and ether starting aid standard. (Ether canister not included.)

transmission

Planetary power shift with choice of three speeds forward, one reverse or three speeds forward, three reverse. Single lever on left side of steering column controls speed and direction. Single-stage torque converter integral with power shift transmission.

Three forward, one reverse transmission	1st	2nd	3rd
Forward, MPH:	4.0	7.2	14.8
km/h:	6.5	11.7	23.9
Reverse, MPH:	—	6.6	—
km/h:	—	10.8	—

Three forward, three reverse transmission			
Forward, MPH:	4.3	8.2	14.6
km/h:	6.9	13.2	23.5
Reverse, MPH:	4.6	8.7	15.5
km/h:	7.4	14.0	24.9

axles

Front axle fixed, rear axle oscillates ±11°, total of 22°. This allows 12" 305 mm vertical travel of one rear wheel with all wheels remaining on the ground. Axle shafts may be removed without removing wheels and planetaries. Optional NoSPIN differential available for front axle.

final drives

All-wheel drive with planetary reduction in each wheel. Planetary units may be removed independently of wheels and brakes.

brakes

Service — Caliper disc brakes standard, mounted on front wheels. Hydraulically actuated. Left pedal applies brakes and neutralizes transmission. Right pedal actuates brakes without neutralizing transmission. Four wheel caliper disc brakes optional.

Parking — Mechanical shoe brake mounted on drive shaft. Operator applies manually. Twist knob on end of lever for adjustment.

Emergency — Manual control through booster. In event of loss of engine power or hydraulic failure, service brakes can still be applied through mechanical linkage by increased effort on brake pedal. Or, use parking brake.

Brake systems conform to OSHA regulations.

tires

(tubeless)
15.5-25, 8 PR L-2 Traction-type.
15.5-25, 12 PR L-2 Traction-type.

steering

Articulated frame. Rear and front wheels track at all times.

Minimum turning radius (over tire) (§)	15'6" 4.720 m
Steering angle (each direction)	35°

bucket control

Single lever to right of operator's seat controls bucket movement. Push the lever forward to lower, pull it back to raise the bucket. Move the lever to the left for tilt back, to the right to dump. Automatic bucket positioner and lift kickout are standard.

hydraulics

Double-section gear pump.

Output:	
Steering and braking @ rated engine RPM @ 2500 psi 172 bar 17 240 kPa	14.0 gpm 53 liters/min
Bucket @ rated engine RPM @ 2500 psi 172 bar 17 240 kPa	22.1 gpm 85 liters/min
Relief valve setting (main)	2500 psi 172 bar 17 240 kPa
Cylinders:	
Lift — bore and stroke	4.00" × 23.88" 102 × 606 mm
Tilt — bore and stroke	3.25 × 21.69" 82.5 × 551 mm

Hydraulic cycle time, rated load in bucket, in seconds (§):

Raise	Dump	Float Down (Empty)	Total
6.1	1.6	3.5	11.2

service refill capacities

		U.S. Gallons	Liters
Fuel tank		29	110
Cooling system		6.6	25
Crankcase		2.9	11
Transmission	3 Forward — 1 Reverse	4	15
	3 Forward — 3 Reverse	6	23
Differential and final drive,			
Front		4	15
Rear		4	15
Hydraulic system (includes tank)		13.7	52
Hydraulic tank		7.9	30

ROPS

(ROPS is required in U.S.A.)
ROPS (Rollover Protective Structures) offered by Caterpillar for this machine meet ROPS criteria: SAE J394, SAE J1040c and ISO 3471. They also meet FOPS (Falling Object Protective Structures) criteria SAE J231 and ISO 3449.

Specifications and ratings conform to all applicable standards recommended by the Society of Automotive Engineers. SAE Standard J732c (1969) and J742b (1969) govern loader ratings, denoted in the text by (§).

910 VALUE ANALYSIS

CAT 3204

- Fuel efficient direct injection engine.
- Performance proven reliability.
- Simple design for easy maintenance.

Planetary Power Shift Transmission

- On-the-go shifting at full rpm.
- Oil-cooled and lubricated.

Durability

- Rugged rear frame of solid steel plate construction.
- Four plate loader tower for solid straddle mounting of lift arms and lift cylinders.
- Solid steel lift arms with outward flare at their base for excellent visibility and better twist absorption.

Center Point Articulation

- Good maneuverability, stability.
- Front and rear wheels track.
- 35° articulation to each side.

Operator's Station

- Rear-attached for good visibility to bucket corners and sure feel of rear frame location.
- Simple, precise bucket controls.
- Flow amplified steering for quick, easy response.

Versatile, Rugged Buckets

- Steel shells and sides resist bending and cracking.
- Corner guard system option for extended life.
- General and multi-purpose buckets available.

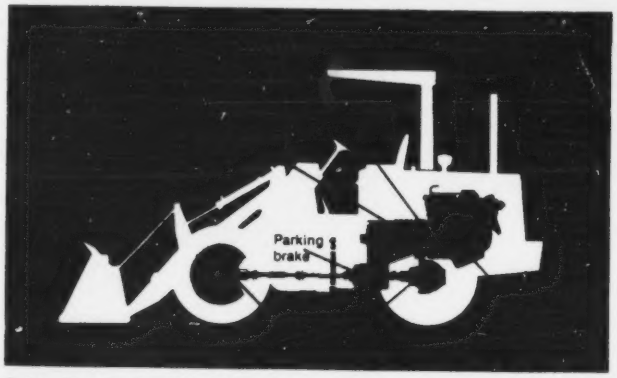
Responsive, Reliable Hydraulics

- 25% more breakout force with larger 3.25" 82.8 mm tilt cylinders.
- Large-bore, short-stroke, cylinders for fast cycle times.
- Automatic bucket controls available with preset capabilities for faster cycling.

High Lift Arrangement

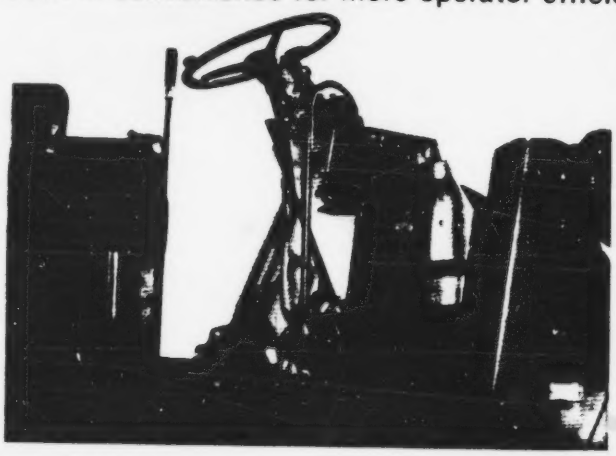
- Dump height capable of loading typical tandem axle trucks with 9 ft/ 2.7 m rail heights.
- Greater reach throughout lift arc than standard lift arms.
- Offset tire rims provide lateral stability.

Reliable Cat power train — efficient, respons



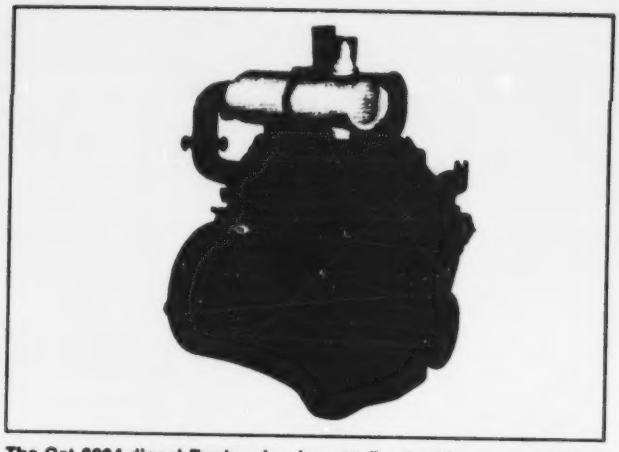
Caterpillar designed and built power train on the 910 delivers the kind of performance and reliability you expect from a Cat Wheel Loader. Cat 3204 diesel Engine with 25% torque rise. Single stage torque converter and planetary power shift transmission for on-the-go shifting. All wheel planetary final drives. Rugged Cat-built components — designed for the work you do.

Built in convenience for more operator efficie

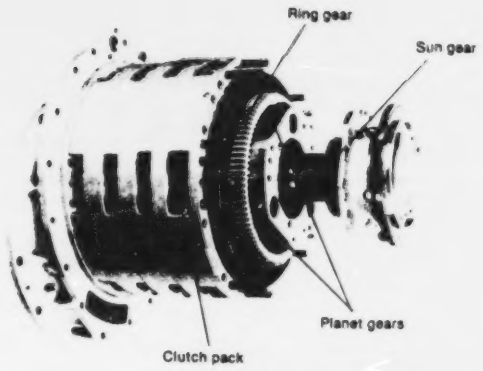


Easy to operate because all controls are simple and logical. Walk-through operator's compartment is clean and uncluttered, allows easy entrance and exit.

ve, versatile.



The Cat 3204 diesel Engine develops 65 flywheel horsepower/48 kW from a big 318 cu. in./5.2 liters displacement, and has a 25% torque rise for strong lugging ability. The 3204 is designed for your work. Adjustment-free fuel system with individual injection pumps meter the correct amount of fuel to each cylinder, with no adjustment required.



Planetary power shift transmission offers choice of three speeds forward, one reverse or three speeds forward, three reverse. Shift on-the-go for quick speed and direction changes, fast cycles. Large oil-cooled clutch packs surround each planetary set for reliable, trouble-free shifting. Single-stage torque converter adjusts speed and rimpull to the load.

icy.

Optional ROPS cab offers many operator comfort and convenience features. The cab allows excellent visibility both front and rear, and has a fully adjustable seat with seat belt, rearview mirror, windshield washer and wiper. Sound-suppression, suspension seat, heater and defroster are optional.

Optional High Lift Arrangement.

Reach — The high lift arrangement gets the load up higher and out farther. The 910 high lift Loader provides greater reach throughout most of the lift arc enabling loads to be properly centered in wider truck bodies. At the standard machine's maximum dump height, 8'0"/2.438 m, the high lift arrangement provides 10.4"/264 mm more reach. At full lift, the 910 high lift loader provides 10"/254 mm more dump clearance than the standard loader.

Operating specifications

Linkage type				
Bucket type				
Capacity, rated [1] nominal heaped [2] (§)	yd³	1	1¼	1½
	m³	0.8	1	1.2
Bucket width	in	72"	84"	96"
	mm	1,828	2,093	2,357
Dump height @ full lift and 45° discharge (§)	ft	8'0"	8'0"	8'10"
	mm	2,438	2,438	2,690
Bottom dump	ft	—	9'2"	—
	mm		2790	
Reach @ full lift and 45° discharge (§)	in	36	33	36.1"
	mm	894	834	917
Reach @ 7'2130 mm height and 45° discharge	ft	5'9"	3'8"	4'3.7"
	mm	1,132	1,090	1,305
Bottom dump	in		33	
	mm		838	
Overall length (§)	ft	18'10"	18'9"	19'10"
	m	5,741	5,706	6,045
Overall height (§)	ft	13'5"	15'2.5"	14'3"
	m	4,085	4,608	4,343
Turning radius — outside corner of bucket in carry position (§)	ft	18'11"	16'10.6"	17'3"
	m	5,156	5,147	5,258
Digging depth	in	3.1"	4.6"	4.5"
	mm	78	117	114
Bucket rackback angle Groundline		38.7°	40°	44.2°
	mm	983	1067	1122
Carry position		45.7°	45°	50.0°
Full lift		61.0°	63°	64.3°
Hinge pin height @ carry position	in	15.6	17"	18.4"
	mm	396	425	465
@ full lift	in	10'1.5"	10'1.5"	10'11"
	m	3,638	3,066	3,330
Static tipping load** Straight (§)	lb	9947	9411	8977
	kg	4511	4269	4072
Full 35° turn (§)	lb	9000	8477	8124
	kg	4082	3845	3685
Breakout force* (§)	lb	12,915	13,849	13,816
	kg	5858	6281	6266
	kN	57.4	61.4	61.2
Operating weight** (§)	lb	14,310	14,261	14,011
	kg	6441	6471	6355

*Breakout force is measured 4" 102 mm behind tip of cutting edge with bucket hinge pin as pivot point.
**Static tipping load and operating weight include ROPS canopy, bucket and 15.5 × 25, 8 PR tires, full fuel tank, and operator.

Machine stability and operating weight are affected by attachments.
Add the following to operating weight and static tipping load:

	Change in Operating Weight		Change in Articulated Static Tipping Load			
			Standard		High Lift Arrangement	
	Lb	Kg	Lb	Kg	Lb	Kg
Add ROPS cab	+381	+173	+255	+115	+231	+105
Remove ROPS canopy	−700	−317	−760	−345	−691	−313
Add 3 Forward-3 Reverse Transmission	+450	+204	+435	+197	+396	+180

standard equipment

12-volt direct electric starting. Ether starting aid. Warning horn. 40-amp alternator. Fuel priming pump. Blower fan. 15.5 - 25, 8 PR tires. Front disc brakes. Adjustable seat. Dry-type air cleaner. Sealed loader linkage. Front and rear working lights. Stop and tail lights. Muffler. Planetary power shift transmission. Instrument panel lights. Hydraulic control. Bucket positioner and lift kickout. Engine enclosure, seat belts.

optional equipment

(with approximate change in operating weight)

	Lb	Kg
Alternator, 75-amp	2.2	1.0
Backup alarm (required in U.S.A)	20	9
Battery, heavy duty	37	17
Brakes, 4-wheel disc	10	5
Buckets,		
1.25 cu. yd./1.0 m^3 General Purpose	838	380
1 cu. yd./0.8 m^3 Multi-Purpose	1,426	647
Bucket teeth, set of 7	90	41
Cab, ROPS (includes seat belt, windshield wiper and washer)	1,080	490
Canopy, ROPS	725	329
Defroster fan	3	1.4
Differentials,		
Low speed	2.2	1.0
NoSPIN, front only	0	0
Fan, suction	no increase	
Fenders, front and rear	88	40
Guard, power train	220	100
Heater, engine coolant	4	1.8
Cab	20	9.1
High lift arrangement	(see spec chart)	
Hydraulic system, for Multi-Purpose bucket	79	36
Lighting system, for cab or canopy	25	11
Highway, directional, hazard, parking and headlights	60	27
Precleaner	6	3
Sound suppression (operator)	37	17
(spectator)	229	104
Speedometer	3	1
Starting system, low temperature	5	2
Steering system, supplemental	37	17
Suspension seat	13	6
Tool kit	15	7
Vandalism protection group, does not include engine enclosures	18	8

910 buckets provide flexibility in matching the machine to job conditions. All are welded construction with abrasion-resistant steel cutting edges. They feature a tapered floor design of approximately 7°, with box-sectioned reinforcing material placed under the floor for increased structural strength. Optional corner guard system allows quick conversion from teeth to a bolt-on edge for clean-up and floor work while absorbing critical bucket corner wear. Available on General Purpose and light material buckets.

General Purpose bucket, for use in most applications, is designed to accept bolt-on teeth, or a bolt-on cutting edge. Integral spill plate helps reduce spillage and weld-on bottom wear plates for extended life.

Multi-Purpose Bucket can be used for loading, bulldozing, and cleaning up debris. Clamshell action grasps pipes, poles and irregular-shaped objects.

Materials and specifications are subject to change without notice.

AEHQ9469 (9-81)
(Replaces AEHQ9379)

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CATERPILLAR

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Machine shown may have optional equipment.

Summary of features

- **Cat 3304 Engine** . . . with 425 cu. in. (7.0 litres) displacement.
- **Bucket options** . . . from 1.50 to 1.75 cu. yd. (1.15 m^3 to 1.35 m^3).
- **Cat designed and manufactured power train** . . . for optimum match, performance and efficiency.
- **Planetary power shift transmission** shifts on-the-go . . . four speeds forward, three reverse . . . for greater operator efficiency and machine productivity.
- **Articulated frame steering** turns short . . . rear wheels track front for reduced rolling resistance and to help avoid road hazards.
- **Caliper disc brakes** on all wheels . . . fade-resistant, less affected by weather than drum-and-shoe brakes.
- **Sealed loader linkage** eliminates daily maintenance on lift arms and bucket hinge pins.
- **Automatic bucket controls** kick out at pre-set dump height . . . bucket positioner automatically returns bucket to pre-set digging angle . . . no need for visual spotting.
- **CAT PLUS** . . . from your Caterpillar Dealer . . . the most comprehensive, total product support system in the industry.

[redacted]

Caterpillar Engine

Flywheel horsepower @ 2200 RPM	80
Displacement	425 cu. in. (7.0 litres)

The net power at the flywheel of the vehicle engine operating under SAE standard ambient temperature and barometric conditions, 85° F. (29° C) and 29.38" Hg (995 mbar), using 35 API gravity fuel oil at 60° F. (15.6° C). Vehicle engine equipment includes blower fan, air cleaner, water pump, lubricating oil pump, fuel pump, muffler, air compressor and alternator. Engine will maintain specified power up to 5,000 ft. (1500 m) altitude.

Cat 4-stroke-cycle diesel Model 3304 with four cylinders, 4.75" (121 mm) bore, 6.0" (152 mm) stroke and 425 cu. in. (7.0 litres) displacement.

Precombustion chamber fuel system with individual adjustment-free injection pumps and valves.

Cam-ground and tapered aluminum alloy pistons with 3-ring design, cooled by oil spray. Steel-backed aluminum bearings. Hi-Electro hardened crankshaft journals. Pressure lubrication with full-flow filtered oil. Dry-type air cleaner with primary and safety elements.

Uses economical No. 2 fuel oil (ASTM Specification D396), often called No. 2 furnace or burner oil, with a minimum cetane rating of 35. Premium quality diesel fuel can be used but is not required.

Two 24-volt direct electric starting systems – standard or low temperature. Glow plugs for preheating precombustion chambers included with both.

920

Wheel Loader

transmission

Full power shift in four forward and three reverse speeds. Provides on-the-go shifting for greater operator efficiency and machine productivity.

Single lever on left side of steering column controls both speed and direction. Rotate the handle for four forward and three reverse speeds. Move the lever forward or back for directional change. A safety lever locks the transmission control in neutral.

Single-stage, single-phase torque converter.

Maximum speeds with 15.5-25, 12 PR (L-2) tires:

		1st	2nd	3rd	4th
Forward,	MPH:	4.0	7.3	11.9	27.2
	(km/h):	(6.4)	(11.7)	(19.2)	(43.8)
Reverse,	MPH:	4.8	8.8	14.4	–
	(km/h):	(7.7)	(14.2)	(23.2)	

axles

Front axle fixed, rear axle oscillates ± 14°, total of 28°, for greater machine stability. One rear wheel can drop or rise a total of 17.3" (439 mm) with all wheels remaining on the ground. Free-floating axle shafts carry torque, not machine weight, for long life. Axle shafts can be removed independently of wheels and planetaries for servicing ease.

Conventional differentials. Torque-proportioning differentials, recommended for slippery underfoot conditions only, are optional.

final drives

All-wheel drive with planetary reduction in each wheel. Torque is developed at the wheel, putting less stress on axle shafts. Planetary units can be removed independently of wheels and brakes for servicing ease.

brakes

(System meets OSHA regulations.)

Service – Caliper discs on all four wheels, air/hydraulic actuated. Fade-resistant, less affected by weather than drum-and-shoe brakes. Separate brake circuits for front and rear axles. Two brake pedals: right pedal brakes only; left pedal brakes while neutralizing transmission.

Parking – Mechanical shoe-type mounted on transmission shaft. Operator applies manually.

Emergency – Uses parking brake. When air pressure drops, an audible warning sounds, then brake automatically applies to bring machine to a controlled stop. Operator can also apply manually.

tires

Tubeless, nylon, loader-dozer design.

Choice of:
13-24, 8 PR (G-2) Traction
15.5-25, 12 PR (L-3) Rock
15.5-25, 12 PR (L-2) Traction

steering

Center-point frame articulation. Rear and front wheels track at all times, for greater operator efficiency, lower rolling resistance, reduced tire wear. Full hydraulic power. Full-flow filtering.

Minimum turning radius (over tires)	17'1" (5210 mm)
Steering angle (each direction)	35°

Hydraulic system – Two 3.0" (76 mm) bore, double-acting cylinders powered by vane-type pump. Pump sized for excellent steering response at all engine speeds.

Output @ 2200 RPM and 1000 psi (69 bar)	25.4 gpm (96 litres/min)
Relief valve setting	2500 psi (172 bar)

bucket controls

Lift circuit – Positions: raise, hold, lower and float. Automatic bucket positioner and lift kickout are standard.

Tilt circuit – Positions: roll back, hold and dump. Automatic bucket positioner adjustable to desired loading angle.

No visual spotting required.

lift arms

Sealed pins in lift arms and bucket hinge points for longer pin and bushing life, lower maintenance costs. Grease once every 100 service meter units, except lower bucket hinge pins, which need grease every 50 SMU.

loader hydraulic system

Sealed with valves enclosed in reservoir to keep out dirt and other contaminants.

Pump output @ 2200 RPM and 1000 psi (69 bar), with SAE No. 10 oil @ 150° F. (66° C)	33.3 gpm (126 litres/min)
Relief valve setting	2500 psi (172 bar)
Cylinders (double-acting):	
Lift – bore and stroke	4.25" x 30.8" (108 x 780 mm)
Tilt – bore and stroke	4.0" x 16.6" (102 x 422 mm)

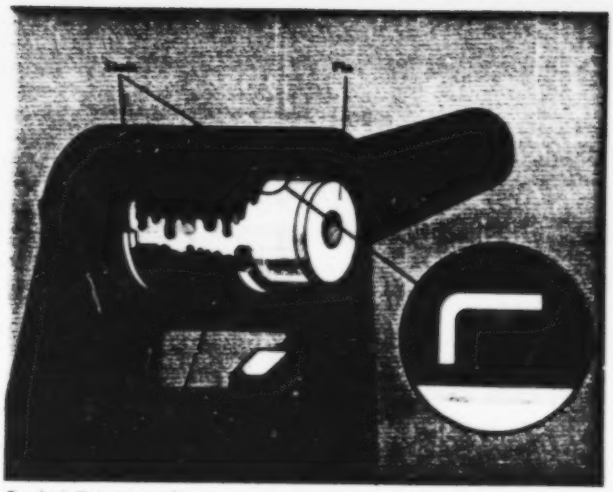
Hydraulic cycle time, rated load in bucket, in seconds (§):

Raise	Dump	Float down (Empty)	Total
6.0	1.2	3.0	10.2

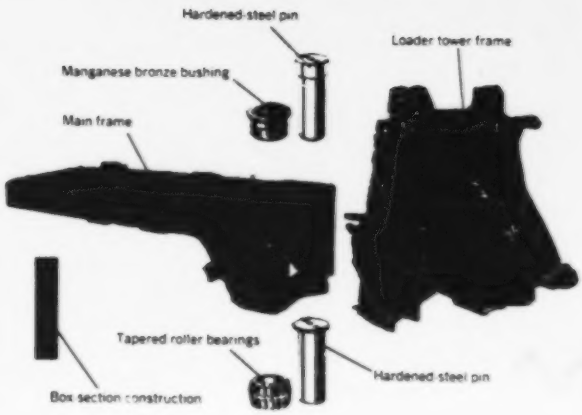
service refill capacities

	U.S. Gallons	(litres)
Cooling system	7.7	(29.1)
Crankcase	5.0	(18.9)
Transmission and torque converter	6.7	(25.4)
Differential and final drives:		
Front	5.5	(20.8)
Rear	5.5	(20.8)
Hydraulic system	19.5	(74)
Hydraulic tank	14.0	(53)
Fuel tank	39.0	(148)

Specifications and ratings conform to all applicable standards recommended by the Society of Automotive Engineers. SAE Standard J732c (1969) and SAE Standard J742b (1969) govern loader ratings, denoted in the text by (§).



Sealed linkage reduces regular greasing of lift arm pivot points to once every 100 service meter units. (Lower bucket hinge pins need grease every 50 SMU.) Lip-type seals on each pin hold the lubricant in and keep out wear-causing grit. Pin and bushings last longer, and less time and money are spent for routine maintenance.



Box-section main frame and loader tower resist twisting and bending on rough ground. Two hardened-steel pins couple the front and rear frames. The bottom pin rides in double-tapered roller bearings; the upper, in a wide-contact manganese bronze bushing. Bucket lift arm pins and hydraulic cylinder mounting pins are supported on both ends by steel plates in the loader tower, rather than on a single side as with cantilever mounting

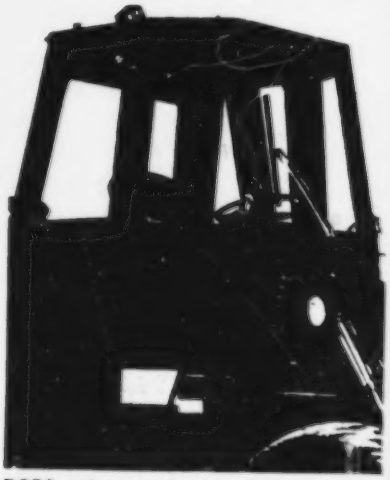
Automatic bucket controls let the operator concentrate on fast maneuvering. The lift lever automatically "holds," then kicks out to stop the hoisting action at a pre-set dump height. The tilt lever also holds when engaged, then kicks out when empty bucket returns to the desired digging angle. Both can be manually overridden.

Cat 3304 Diesel Engine . . . with 425 cu. in. (7.0 litres) displacement . . . delivers reliable power to keep your job moving. The adjustment-free fuel system has individual fuel injection pumps and valves to meter fuel precisely for efficient performance. Cam-ground and tapered aluminum alloy pistons expand at operating temperatures to fit snugly in the cylinders for smooth, even power flow.

Four-wheel caliper disc brakes stop the 920 dependably and quickly. They're self-adjusting for wear . . . and self-cleaning in mud and grime to resist fading. Separate hydraulic circuits on front and rear axles insure two-wheel braking ability if one circuit is lost.

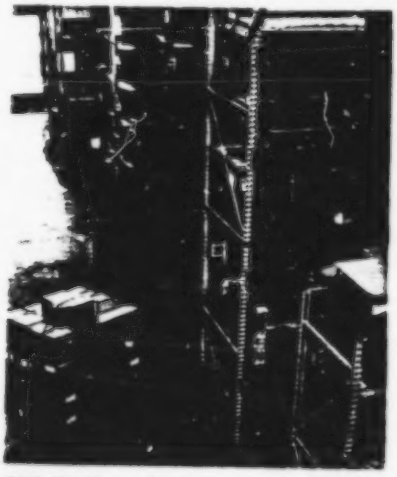
Planetary power shift transmission is designed for tough work . . . with big clutch packs. Hydraulic modulation cushions clutch engagement for full-power, on-the-go shifting. Planet gears spaced 120° apart spread out stresses for longer life. Oil cooling and lubrication reduce heat and wearing friction.

A single lever on the steering column controls both speed and direction. Rotate it to select four speeds forward and three in reverse . . . move it forward or back for directional change. It's simple, convenient and quick.



ROPS cab (standard in U.S.A.) offers operator protection, plus comfort and convenience. It gives excellent visibility both front and rear, and includes windshield washer and wiper and seat belt. Optional sound suppression, suspension seat and Cat air conditioner/heater/defroster add to operator comfort and encourage maximum production.

35° articulated steering provides quick, efficient maneuvering. The 920 can load, maneuver and dump in less than two machine lengths. With exact center-point articulation, the front and rear wheels always track, reducing tire wear and rolling resistance.



CAT PLUS – the most comprehensive, total product support system in the industry – comes with every 920 Wheel Loader. Your Caterpillar Dealer provides product application counseling and flexible finance planning before you buy, and these services after:

- Planned inspection programs.
- Preventive maintenance programs.
- Parts support.
- Parts Exchange Service.
- In-field service.
- Machine customizing services.
- Complete range of technical assistance.
- Personnel training for operators and mechanics.
- Cat Care seminars.

CAT PLUS

Sealed hydraulics keep out dirt and grime that can damage hydraulic components. There are no external breathers to let in contaminants.

Operating Specifications

Capacity, struck (§)	1.19 cu. yd. (0.91 m³)	1.37 cu. yd. (1.05 m³)	1.29 cu. yd. (0.99 m³)	1.26 cu. yd. (0.96 m³)
Cutting edge, type	Straight	Straight	Straight	Straight
Width (§)	96" (2419 mm)	95" (2419 mm)	95" (2419 mm)	107" (2715 mm)
Dump clearance @ full lift and 45° discharge (§)	9'1" (2770 mm)	9'0" (2740 mm)	8'7" (2620 mm)	8'10" (2690 mm)
Side Dump clearance	—	—	—	10'5" (3170 mm)
Reach at 45° discharge, 70° (2130 mm) clearance (§)	4'0" (1220 mm)	4'1" (1240 mm)	4'0" (1220 mm)	4'2" (1270 mm)
Reach at full lift and 45° discharge (§)	29" (740 mm)	30" (760 mm)	32" (810 mm)	32" (810 mm)
Digging depth (§)	2.6" (66 mm)	2.6" (66 mm)	4.8" (122 mm)	2.3" (58 mm)
Overall length (§)	18'9" (5.7 m)	18'10" (5.7 m)	19'5" (5.9 m)	19'1" (5.8 m)
Overall height (§)	14'8" (4470 mm)	15'0" (4570 mm)	15'2" (4620 mm)	15'1" (4600 mm)
Loader clearance circle (bucket in carry position) (§)	36'7" (11.2 m)	36'8" (11.2 m)	36'11" (11.3 m)	38'8" (11.8 m)
Bucket weight, without teeth	1,370 lb. (620 kg)	1,550 lb. (700 kg)	2,345 lb. (1060 kg)	1,740 lb. (790 kg)
With teeth	1,630 lb. (740 kg)	1,750 lb. (790 kg)	2,585 lb. (1170 kg)	1,740 lb. (790 kg)
Static tipping load,**				
Straight (§)	13,057 lb. (5923 kg)	13,214 lb. (5994 kg)	12,105 lb. (5491 kg)	12,573 lb. (5703 kg)
Full 35° turn (§)	12,290 lb. (5570 kg)	12,260 lb. (5560 kg)	11,290 lb. (5120 kg)	11,710 lb. (5310 kg)
Breakout force* (§)	17,680 lb. (8020 kg)	16,560 lb. (7510 kg)	14,440 lb. (6550 kg)	15,240 lb. (6910 kg)
Operating weight**	18,553 lb. (8416 kg)	18,558 lb. (8418 kg)	19,103 lb. (8665 kg)	18,813 lb. (8534 kg)

*Measured 4" (102 mm) behind tip of cutting edge with bucket hinge pin as pivot point, in accordance with SAE J732c (1969).

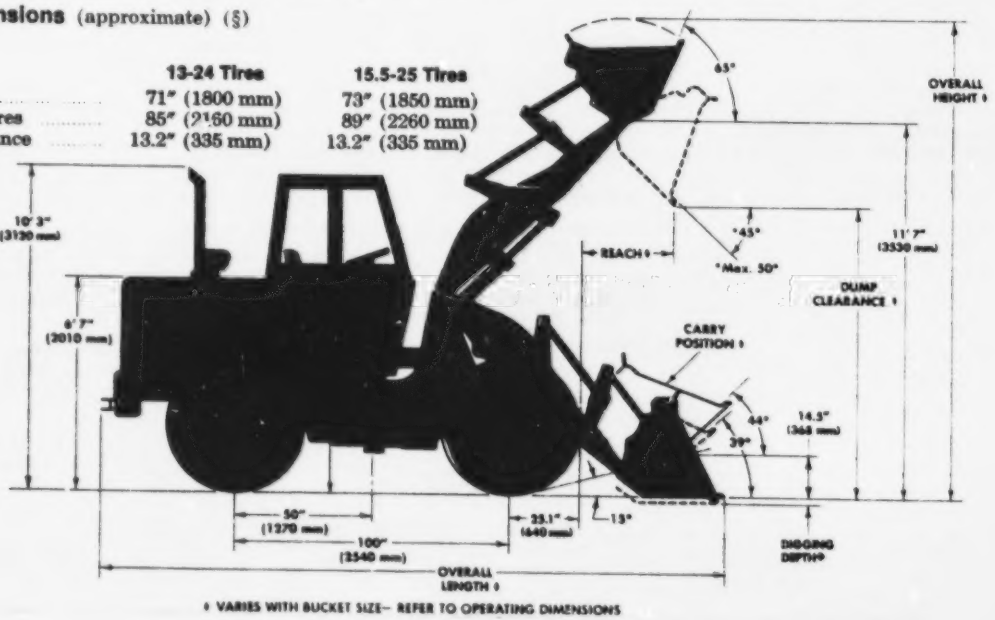
**Static tipping load and operating weight include lubricants, coolant, full fuel tank, 15.5-25, 12 PR (L-2) tires with 850 lb. (386 kg) $CaCl_2$ solution in rear tires, ROPS cab and operator. Machine stability is affected by the tire size, tire ballast or attachments. For selected items add the following to machine operating weight and static tipping load:

	Change in Operating Weight	Change in Articulated Static Tipping Load
15.5-25, 12 PR (L-2) tires	–850 lb. (–386 kg)	–1,080 lb. (–490 kg)
15.5-25, 12 PR (L-3) tires	–750 lb. (–340 kg)	–1,010 lb. (–458 kg)
15.5-25, 12 PR (L-3) tires w/75% $CaCl_2$	160 lb. (72 kg)	140 lb. (63 kg)
13-24, 8 PR (G-2) tires †	–1,230 lb. (–560 kg)	–1,780 lb. (–810 kg)
13-24, 8 PR (G-2) tires w/75% $CaCl_2$	–430 lb. (–195 kg)	–770 lb. (–349 kg)
Counterweight	740 lb. (336 kg)	1,260 lb. (570 kg)
Without ROPS cab	–840 lb. (–381 kg)	–750 lb. (–340 kg)
Canopy, ROPS †	–220 lb. (–100 kg)	–200 lb. (–91 kg)

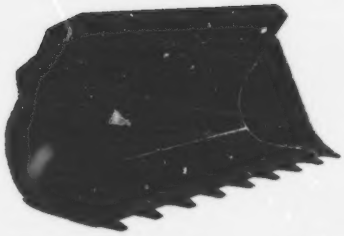
†Tire ballast in all wheels recommended when ROPS installed with 13-24 tires.

dimensions (approximate) (§)

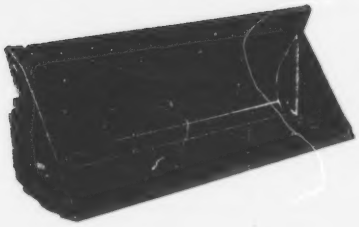
	13-24 Tires	15.5-25 Tires
Tread width	71" (1800 mm)	73" (1850 mm)
Width over tires	85" (2160 mm)	89" (2260 mm)
Ground clearance	13.2" (335 mm)	13.2" (335 mm)



◊ VARIES WITH BUCKET SIZE— REFER TO OPERATING DIMENSIONS



General Purpose Buckets are made from high-strength, wear-resistant steel plate and bracing, joined by 100% penetration welds. Forged corners, straight-through cutting edge, side plates, bottom replaceable wear plates and reinforced hinge guards are heat treated to last longer. Nine teeth with long or short tips are optional.



Multi-Purpose Bucket loads, bulldozes, strips top soil, cleans up debris, etc. 740 lb. (336 kg) counterweight recommended. Additional hydraulic valve required. Optional teeth aid digging.

Side Dump Bucket dumps forward or to the left. Reduces turning, aids close-quarter loading. 740 lb. (336 kg) counterweight recommended. Additional hydraulic valve required.

standard equipment

Alternator, 35-amp.
Electric starting.
Blower fan.
Torque converter.
Fuel priming pump.
Muffler.
Fenders.
Power shift transmission.
Hydraulically boosted brakes.
ROPS cab (U.S.A. only).
Adjustable seat.
Seat belt.
Front and rear working lights.
Stop and tail lights.
Dry-type air cleaner.
Warning horn.

Gauges and indicators:
Engine water temperature.
Ammeter.
Engine oil pressure.
Fuel pressure.
Torque converter oil temperature.
Hour meter.
Parking brake.

optional equipment

(with approximate installed weights)

Air conditioner/heater/defroster	290 lb. (132 kg)
Compressor only	50 lb. (23 kg)
Alternator, 50 amp	15 lb. (7 kg)
Buckets	see Operating Specifications
Bucket cutting edges (bolt-on) for General Purpose Buckets:	
Flat, reversible, with interchangeable ends	185 lb. (84 kg)
Bucket teeth (bolt-on), 8, for Multi-Purpose and General Purpose Buckets:	
Long tip, each	25 lb. (11 kg)
Short tip, each	12 lb. (5 kg)
Cab, ROPS, includes windshield washer and wiper (standard in U.S.A.)	840 lb. (381 kg)
ROPS, sound-suppressed	920 lb. (417 kg)
Canopy, ROPS	620 lb. (290 kg)
Clamp, top, for lumber fork	540 lb. (245 kg)
Counterweight	740 lb. (336 kg)
Differential, Detroit NoSPIN Rear axle only	10 lb. (4.5 kg)
Drawbar, rear	32 lb. (15 kg)
Fan, reversible blade	14 lb. (6 kg)
Fork, lumber	1,160 lb. (530 kg)
Guard, power train	240 lb. (109 kg)
Heater, cab, includes defroster	120 lb. (54 kg)
Engine coolant	3 lb. (1 kg)
Hydraulic systems:	
For Multi-Purpose Bucket	115 lb. (52 kg)
For Side Dump Bucket or top clamp	85 lb. (39 kg)
Lighting system, 2 lights, for cab	5 lb. (2 kg)
Precleaner	15 lb. (7 kg)
Seat, suspension type, adjustable	30 lb. (14 kg)
Starting system, low temperature	65 lb. (29 kg)
Steering system, supplemental	91 lb. (41 kg)
Tire inflation kit	6 lb. (3 kg)
Tires	see Operating Specifications
Tool kit	18 lb. (8 kg)
Vandalism protection:	
Instrument panel guard	6 lb. (3 kg)
Cap locks for:	
Oil filler	3 lb. (1 kg)
Oil dipstick	4 lb. (2 kg)
Fuel tank	1 lb. (0.5 kg)
Hydraulic tank	1 lb. (0.5 kg)
Radiator	4 lb. (2 kg)

Materials and specifications are subject to change without notice

AEHQ9267 (10-82)
(Replaces AEO49119)

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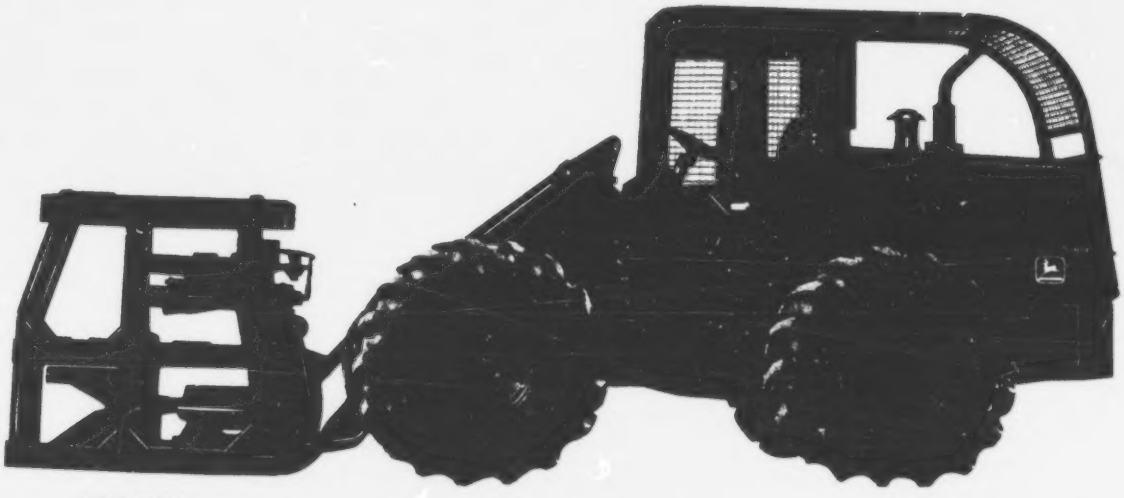
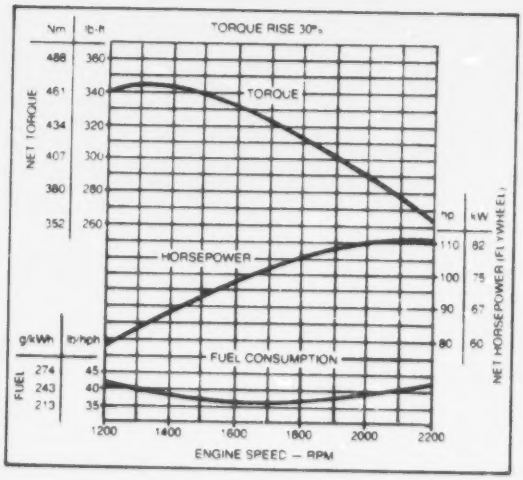
Printed in U.S.A.



AMEC SHEAR

Equipped with AMEC Forestry Protection Package

ENGINE PERFORMANCE



Fuel consumption rate based on maximum horsepower at each net torque requirement. Depending on operation variables, a typical duty cycle averages about one-half of maximum fuel usage.

* To be ordered from AMEC,
Cedartown, GA

FEATURES

110 SAE net hp (82 kW)

4-wheel drive

Twin-turbine torque converter with Power Shift transmission, 4 speeds forward, 2 reverse

Power steering. Articulated frame

4-wheel power wet-disk brakes and parking brake

Inboard planetary final drives

Brake-actuated transmission disconnect

NoSPIN front differential

Increased hydraulic flow

Triple function hydraulics w/dual lever control

High-capacity control valve with one-inch ID plumbing for shear circuit

Forestry canopy w/AMEC protection package*, including rear bumper and guarding

Roll-over protective structure (ROPS) w/canopy. Meets criteria of SAE J394, SAE J1040A, and ISO 3471. Also meets FOPS (falling object protective structure) criteria SAE J231 and ISO 3449.

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WINCHES AND LOG ARCHES

94 Winches for Crawlers
95 3600 Integral Log Arch

544C FELLER-BUNCHER SPECIFICATIONS

(Specifications and design are subject to change without notice. Wherever applicable, specifications are in accordance with ICED and SAE Standards. Except where otherwise noted, specifications are based on a machine equipped with 23.1-26, 10 PR, LS2 tires, full fuel tank, 175-lb (79 kg) operator and standard equipment.)

Power (@ 2200 engine rpm):	SAE	DIN
Gross	120 hp (90 kW)	
Net	110 hp (82 kW)	82 kW

Net engine power is with standard equipment including air cleaner, exhaust system, alternator and cooling fan. Gross power is without cooling fan. Power ratings are at standard conditions per SAE J1349 and DIN 70 020. No derating is required up to 10,000 feet (3050 m) altitude.

Engine: John Deere turbocharged diesel, 6-cylinder, 4-stroke cycle

Bore and stroke	4.19 × 5 in. (106.5 × 127 mm)
Piston displacement	414 cu. in. (6.785 L)
Compression ratio	16.2 to 1
Maximum torque @ 1300 rpm	342 lb-ft (464 Nm) (47.3 kg-m)
Torque rise	30 percent
NACC or AMA (U.S. Tax) horsepower	42
Lubrication	Pressure system w/full-flow filter
Cooling	Pressurized w/thermostat and controlled bypass
Fan	Blower
Air cleaner w/restriction indicator	Dry
Electrical system	12-volt w/alternator
Batteries (two 12-volt) 25 amps at 80° F (27° C)	Reserve capacity 170 minutes each
BCI group 31 cold cranking capacity at 0°F (−18°C)	625 amps
Alternator: standard	42 amps
optional	62 amps

Torque Converter:

Type	Twin-turbine
Torque multiplication	5.19 to 1

Transmission Power Shift planetary

		mph	km/h
Forward Speeds:	1	0-2.9	0-4.7
	2	2.9-6.9	4.7-11.1
	3	0-10.9	0-17.5
	4	10.9-22.8	17.5-36.7
Reverse Speeds:	1	0-3.9	0-6.3
	2	3.9-9.3	6.3-15.0

Note: Shift from 1st to 2nd and 3rd to 4th is automatic.

Differentials:

Front	NoSPIN
Rear	Standard

Drive Axles:

Inboard-mounted planetary gears to each wheel. Front axle fixed. Rear axle oscillates 22 degrees total. Vertical travel at tire centerline 15.06 in. (383 mm).

Brakes:

Service: Power actuated, 4-wheel inboard-mounted wet disk. Foot-operated by either right or left pedal. Left pedal operates transmission disconnect.

Parking: 10 × 1.5-inch (254 × 38 mm) expanding shoe on transmission output shaft. Foot-operated transmission disconnect. Warning light on instrument panel. Warning buzzer.

Steering: Power

Frame articulated 80 degrees by two hydraulic cylinders.

Turning radius to centerline of outside tire	14 ft. 11.4 in. (4.56 m)
Cylinder size: Stroke	15.75 in. (400 mm)
Bore	3 in. (76 mm)
Rod diameter	1.5 in. (38 mm)

Hydraulic System:

Feller-buncher functions: Independent engine-driven gear-type pump delivers 54.7 gpm (3.5 L/s) at 600 psi (4137 kPa) (42.2 kg/cm²) and 2200 engine rpm. 3000 psi (20 684 kPa) (211 kg/cm²) relief valve pressure setting.

Control: Dual lever, triple hydraulic valve

Steering and brakes: Engine-driven, 8 piston, variable-displacement pump delivers 20.6 gpm (1.30 L/s) at 1800 engine rpm and 2000 psi (13 790 kPa) (140.6 kg/cm²). Maximum system pressure is 2400 psi (16 548 kPa) (168.7 kg/cm²).

Hydraulic Cylinders:	Bore	Stroke
Lift, two	5.50 in. (140 mm)	24.3 in. (617 mm)
Tilt, one	5.50 in. (140 mm)	30.6 in. (777 mm)
Lift cylinder rods		2.50 in. (64 mm) dia
Tilt cylinder rod		2.66 in. (68 mm) dia

Cylinder rods are ground, heat-treated, chrome-plated, polished.

Tires:

23.1-26, 10 PR, LS2
23.1-26, 16 PR, LS2
28.1-26, 14 PR, LS2

Capacities:	U.S.	Liters
Fuel tank	40 gal	151.4
Cooling system	27 qt.	26
Crankcase	18 qt.	17
Crankcase including filter	20 qt.	19
Transmission case and filters	39 qt.	37
Front differential	24 qt.	23
Rear differential	25 qt.	24
Loader hydraulic sump	56 qt.	53

Additional Standard Equipment:

Adjustable vinyl seat
Alternator, 42 amp
Antifreeze
Articulation lock
Batteries, low maintenance
Cigaret lighter
Forestry canopy w/instrument panel cover and seat belt
Fuel filter
Gauges:
- Coolant temperature
- Electric hourmeter
- Engine oil pressure
- Fuel
- Transmission oil pressure
- Transmission oil temperature
- Voltmeter

Hand grips
Hydraulic tube shield
Instrument panel warning lights:
- Hydraulic filter bypass
- Parking brake

Key switch
Muffler
Precleaner
Pushbutton safety start
Reverse warning alarm
Toolbox
Transistorized voltage regulator
Transmission disconnect
Tubocharged with aspirated air cleaner

SAE Operating Weight w/AMEC Protection Package and w/o Shear 22,690 lb. (10 314 kg)

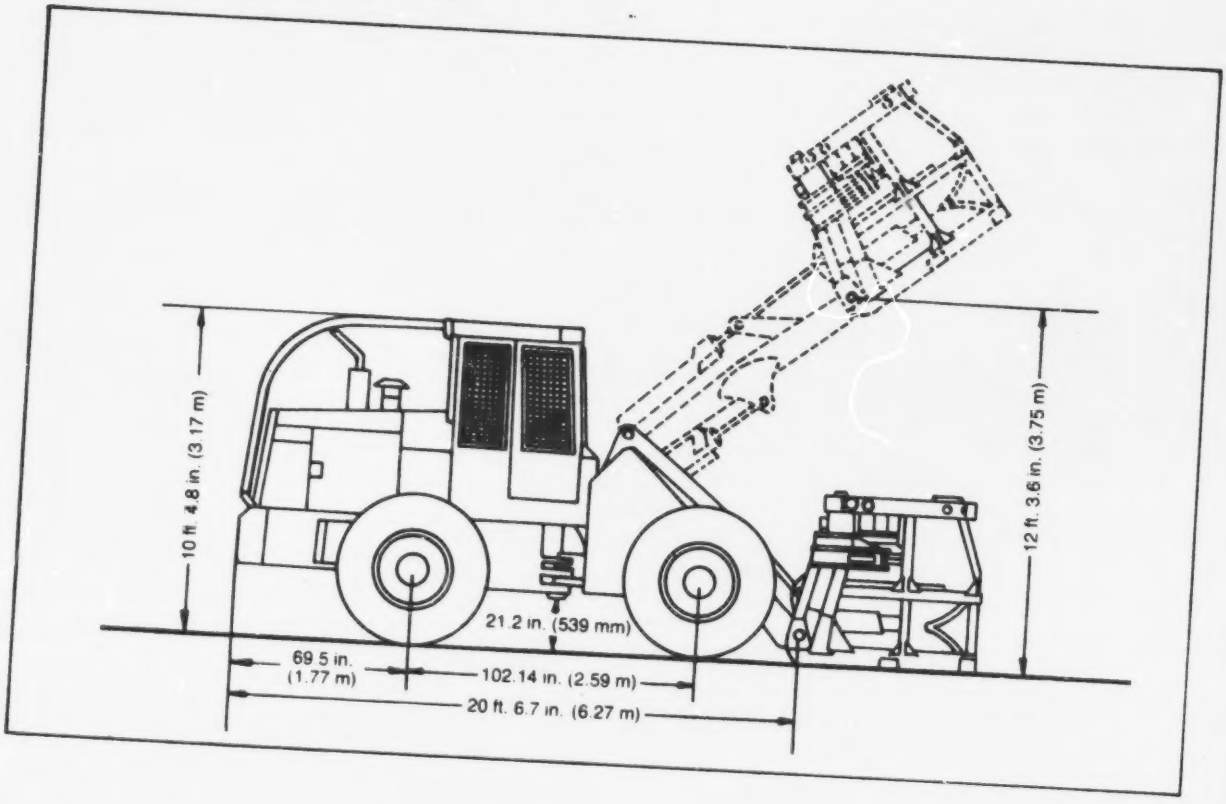
Optional or Special Equipment:

Adjustable deluxe vinyl seat
Adjustable deluxe vinyl seat w/suspension
Alternator, 62 amp
AMEC forestry protection package* with:
- Canopy screens
- Heavy-duty hood
- Heavy-duty bottom guards w/hinged access doors
- Heavy-duty side shields
- Hose guards in hinge area
- Limb risers
- Rear bumper w/fixed drawbar

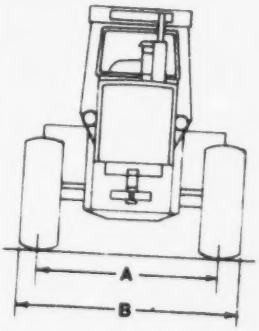
Emergency steering
Engine coolant heater
Ether starting aid
Floor mat
Heater for canopy
License plate bracket
Pest covers
Radio
Rear wiper cover
SMV emblem
3-in. (76 mm) seat belt
Vandal protection

*To be ordered from AMEC, Cedartown, GA

544C FELLER-BUNCHER DIMENSIONS



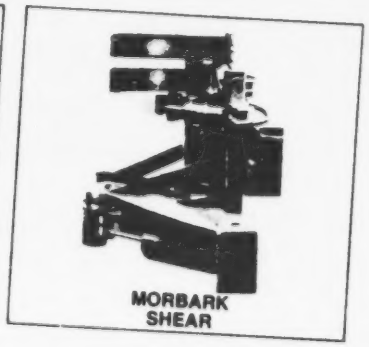
	A Wheel Tread	B Overall Width
23.1-26	78.12 in. (1.98 m)	101.12 in. (2.57 m)
28 1-26	89.52 in. (2.27 m)	117.92 in. (3.0 m)

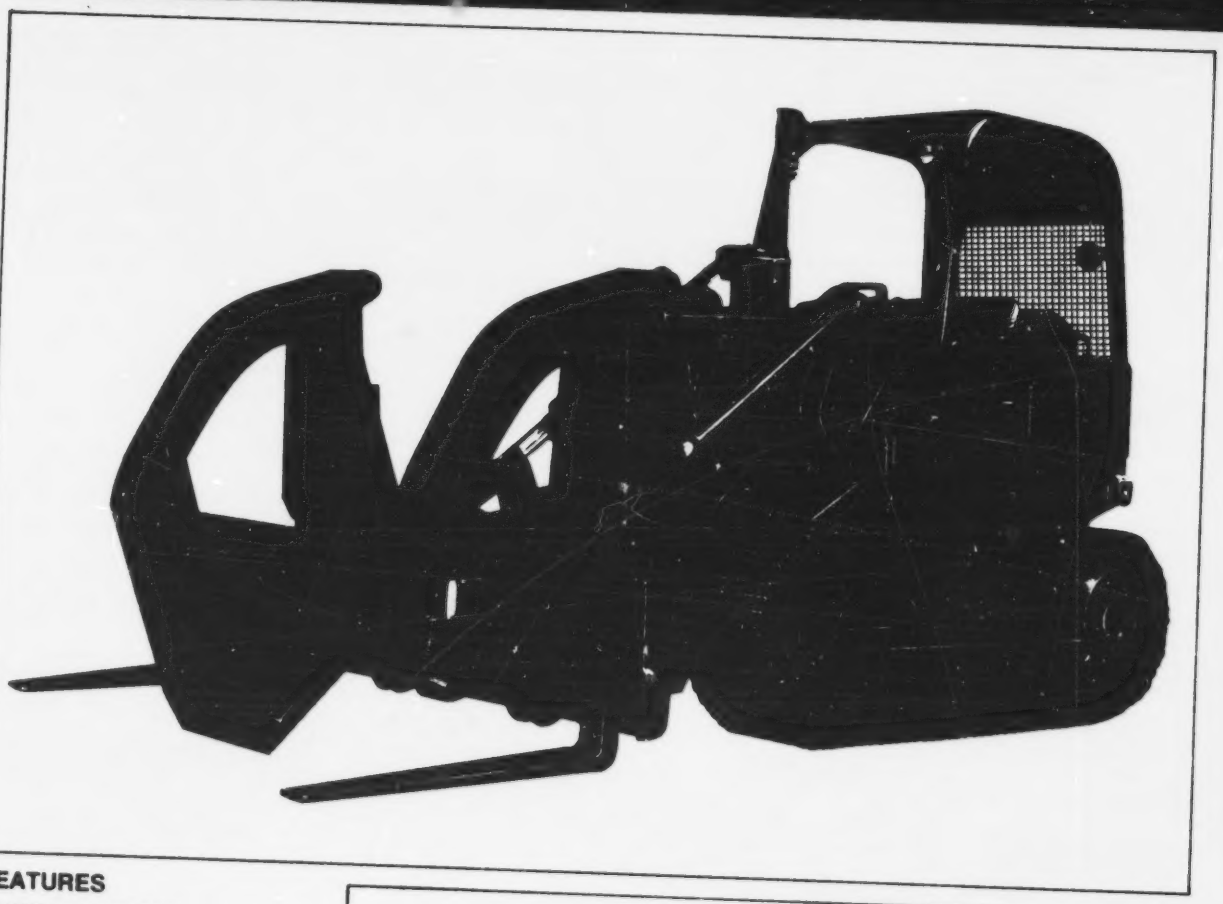


Adaptable for shears such as AMEC, Harricana and Morbark.

AMEC SHEAR

HARRICANA SHEAR


MORBARK SHEAR



FEATURES

78 SAE net hp (58 kW)

Dual-lever loader control

Tine level indicator

Power Shift transmission with torque converter

8600-pound (3900 kg) lifting capacity, full height

Dura-Trax™ undercarriage with boron-steel deep-heat-treated, strutted, sealed track links; deep-heat-treated sealed rollers; boron-steel through-hardened grousers; sealed front idler and carrier roller

Self-adjusting, oil-cooled steering clutches and brakes

Pedal steering

Return to level

Roll-over protective structure (ROPS)

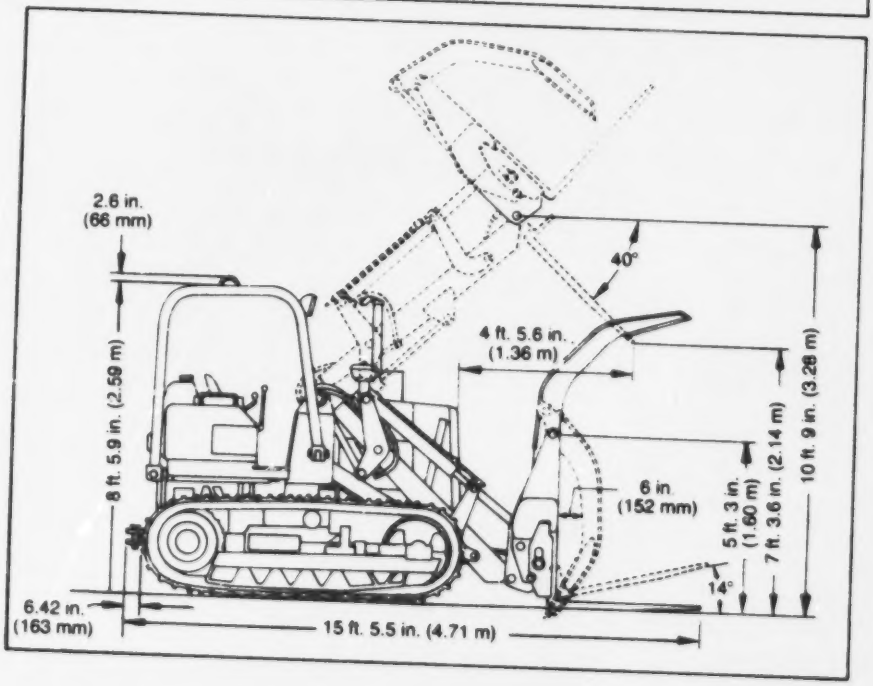
Vandal protection

ADD VERSATILITY WITH:

Winch

Fairlead and drawbar

Integral log arch



555A LOG AND LUMBER LOADER SPECIFICATIONS

(Specifications and design subject to change without notice. Wherever applicable, specifications are in accordance with ICED and SAE Standards. Except where otherwise noted, these specifications are based on a unit equipped with clamp, full fuel tank, 175-lb. (79 kg) operator and standard equipment.)

Power (@ 2200 engine rpm):	**SAE**	**DIN**
Gross	86 hp (64 kW)	
Net	78 hp (58 kW)	58 kW

Net engine power is with standard equipment including air cleaner, exhaust system, alternator and cooling fan. Gross power is without cooling fan. Power ratings are at standard conditions per SAE J1349 and DIN 6270. No derating is required up to 10,000 feet (3050 m) altitude.

Engine: John Deere turbocharged diesel, 4-cylinder, 4-stroke cycle

Bore and stroke	4.19×5.00 in. (106.4×127 mm)
Piston displacement	276 cu. in. (4.523 L)
Compression ratio	16.2 to 1
Maximum torque @ 1300 rpm	250 lb-ft (329 Nm) (34.6 kg-m)
Torque rise	34 percent
NACC or AMA (U.S. Tax) horsepower	28
Lubrication	Pressure system w/full-flow filter and cooler
Main bearings	5
Cooling	Pressurized w/dual thermostat and controlled bypass
Fan	Blower
Air cleaner w/restriction indicator	Dry, dual element
Electrical system	12-volt
Battery	Reserve capacity: 180 minutes

Transmission ..... Converter-driven, 3-speed forward and reverse, Power Shift

Range:

	Travel Speeds: mph		km/h	
	Fwd.	**Rev.**	**Fwd.**	**Rev.**
1	2.0	2.4	3.2	3.9
2	3.3	3.9	5.3	6.3
3	5.6	6.8	9.1	10.9

Steering:

Steering clutches and brakes are controlled by a single pedal for each track. A separate pedal provides braking and lock-down for parking.

Clutches ..... Oil-cooled, hydraulically actuated, multiple-disk, 11-in. (279 mm) disk; 16 friction surfaces per clutch.

Brakes ..... Self-adjusting, self-energizing, oil-cooled contracting band with bonded lining.

Hydraulic System:

Control	Triple hydraulic valve with single-lever boom and rollback control and third function control
Pump	Gear, 28 gpm (1.77 L/s)
Pressure	2500 psi (17 238 kPa) (175.8 kg/cm²)
Oil lines	Seamless steel tubing, double-wire-braid hose
Filter	Spin on, micronic

Hydraulic Cylinders:	**Bore**	**Stroke**
Boom, (2)	4.25 in. (108 mm)	28.25 in. (718 mm)
Fork, (2)	3.5 in. (89 mm)	31.1 in. (790 mm)
Clamp (2)	5.25 in. (133 mm)	16.8 in. (427 mm)
Cylinder rods	Ground, heat-treated, chrome-plated, polished	
Boom cylinder rods	2.25 in. (57 mm) dia.	
Fork cylinder rods	1.75 in. (44.5 mm) dia.	
Clamp rods	2.25 in. (57 mm) dia.	

Undercarriage: 5 roller track frame with full-length rock guards. Dura-Trax™ deep-heat-treated components.

Triple semi-grouser, open-center shoes	14-in. (356 mm)
Track shoes, each side	37
Ground contact area	2128 sq. in. (13 729 cm²)
Ground pressure (w/basic fork)	8.7 psi (60 kPa) (0.612 kg/cm²)
Length of track on ground	76 in. (1.93 m)
Track gauge	52 in. (1.32 m)
Carrier roller	1
Adjustment	Hydraulic
Clearance at rear crossbar	14.25 in. (362 mm)

Operating Information:

Lifting capacity, full height, measured at 24 in. (610 mm) from heel of fork, with load centered:	
w/o clamp	8600 lb. (3900 kg)
w/clamp	7250 lb. (3290 kg)
Minimum dia. w/clamp closed	6 in. (152 mm)
Length of tines (heel-to-toe)	4 ft. (1.22 m)
Tine spacing (center-to-center), adjustable	15 in. (381 mm)
	21.5 in. (546 mm)
	43 in. (1.09 m)
	58 in. (1.47 m)
	70 in. (1.78 m)
Maximum dump angle	40 deg.
Rollback at ground level:	
w/o clamp	19 deg.
w/clamp	14 deg.

Capacities:	**U.S.**	**Liters**
Cooling system	5 gal.	18.9
Fuel tank	36 gal.	136.3
Crankcase, including filter	15 qt.	14.2
Transmission	13.5 gal.	51.1
Final drive (each)	7 qt.	6.6
Loader hydraulic reservoir	7 gal.	26.5
Loader hydraulic system	13 gal.	49.2
Steering clutch housing (each side)	28 qt.	26.5

Additional Standard Equipment:

Boom safety lock bar
Bottom guard counterweight w/fixed drawbar
Bucket level indicator
Cushion seat w/armrests
Cold-weather starting aid
Decelerator
Electric hourmeter
Enclosed alternator w/solid state regulator
Front bottom guard
Front hitch
Front idler shields
Horn
Isolation-mounted ROPS w/seat belt
Key switch
Lights
Master electrical disconnect switch
Muffler
Perforated engine sideshields
Precleaner
Pushbutton start
Radiator sandshield
Return-to-level
Sprocket weights
Tachometer
Tine level indicator
Vandal protection

SAE Operating Weight w/ROPS:

w/o clamp	19,395 lb. (8800 kg)
w/clamp	20,545 lb. (9320 kg)

Special Equipment:

Brush screens
Cigaret lighter
Limb risers w/overhead exhaust
Log inserts
Rear counterweight for log loader
ROPS cab
Two batteries
Winch drive

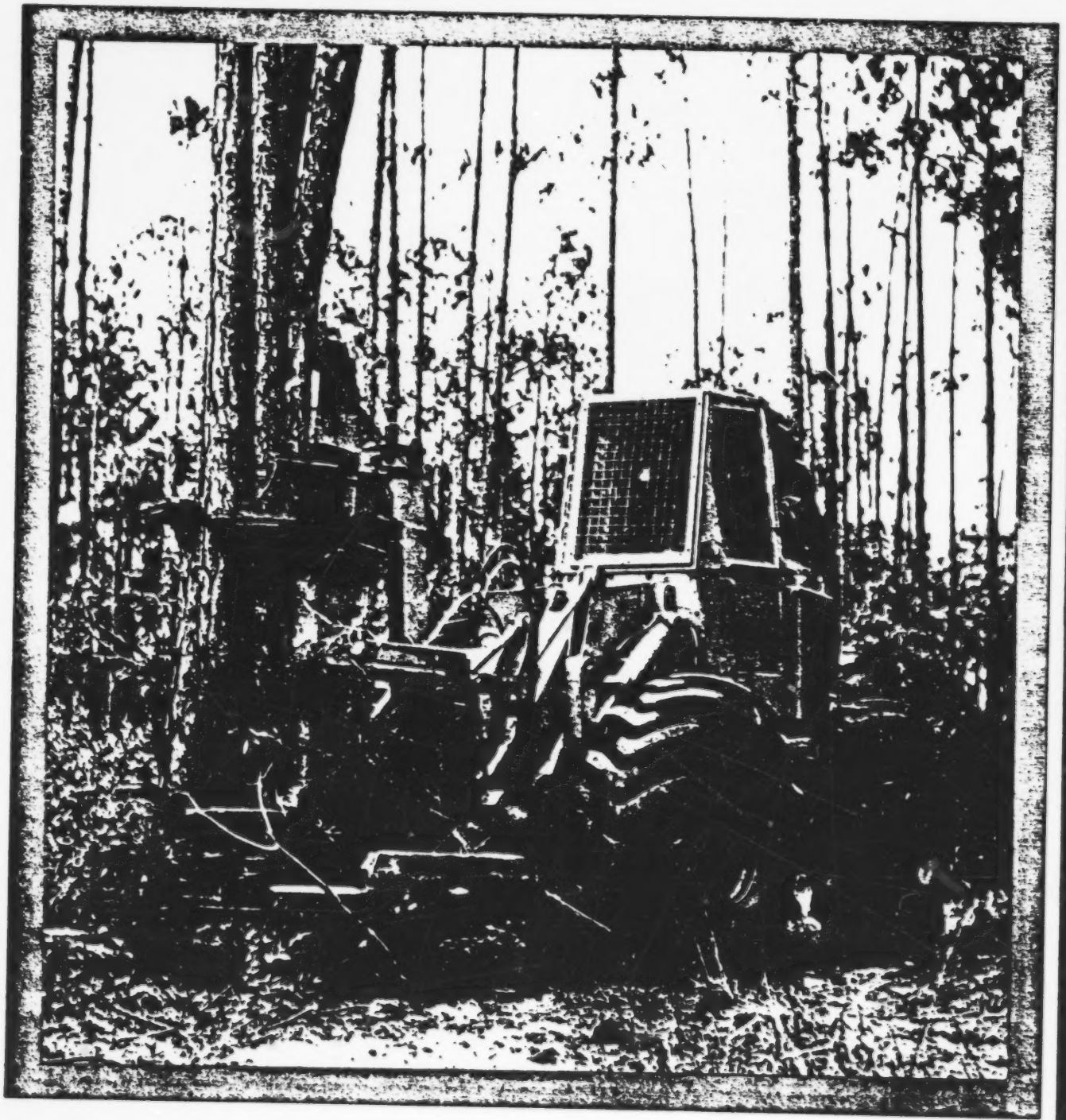
137

Feller-Bunchers
For Cat-Built Loaders

20 Inch Cutting Capacity
15 Inch Cutting Capacity

950 955
930 951
920 941
910 931

FLECO



Feller-Bunchers For Cat-Built Loaders

20 Inch Cutting Capacity

Length	68"	(1727 mm)	Minimum Clamp Closed Diameter	1"	(25 mm)
Width	84"	(2134 mm)	Maximum Clamp Tip Opening	23½"	(597 mm)
Height	74"	(1880 mm)	Number of shear blades	2	
Number of Cylinders	4		Blade Thickness	¾"	(19 mm)
Shear Cylinder Diameter	6"	(152 mm)	Cutting Capacity (Softwood)	20"	(508 mm)
			(Hardwood)	17"	(432 mm)
Clamp Cylinder Diameter	3"	(76 mm)	Weight, approximate lbs.	3880	(1760 kg)

With accumulator add 26" (660 mm) to height and 690 lbs. (313 kg) to weight.

15 Inch Cutting Capacity

Length	41"	(1041 mm)	Minimum Clamp Closed Diameter	3"	(76 mm)
Width	56"	(1422 mm)	Maximum Clamp Tip Opening	17"	(432 mm)
Height	50"	(1041 mm)	Number of shear blades	2	
Number of Cylinders	4		Blade Thickness	5/8"	(16 mm)
Shear Cylinder Diameter	5"	(127 mm)	Cutting Capacity (Softwood)	15"	(381 mm)
			(Hardwood)	12"	(305 mm)
Clamp Cylinder Diameter	2½"	(64 mm)	Weight, approximate lbs.	1650	(748 kg)

With accumulator add 26" (660 mm) to height and 485 lbs. (220 kg) to weight.

FLECO JACKSONVILLE, FLORIDA U.S.A.

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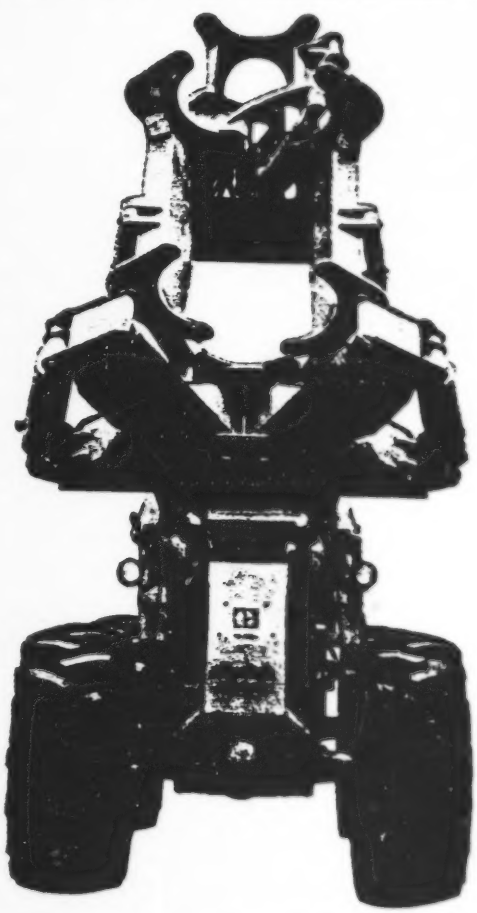
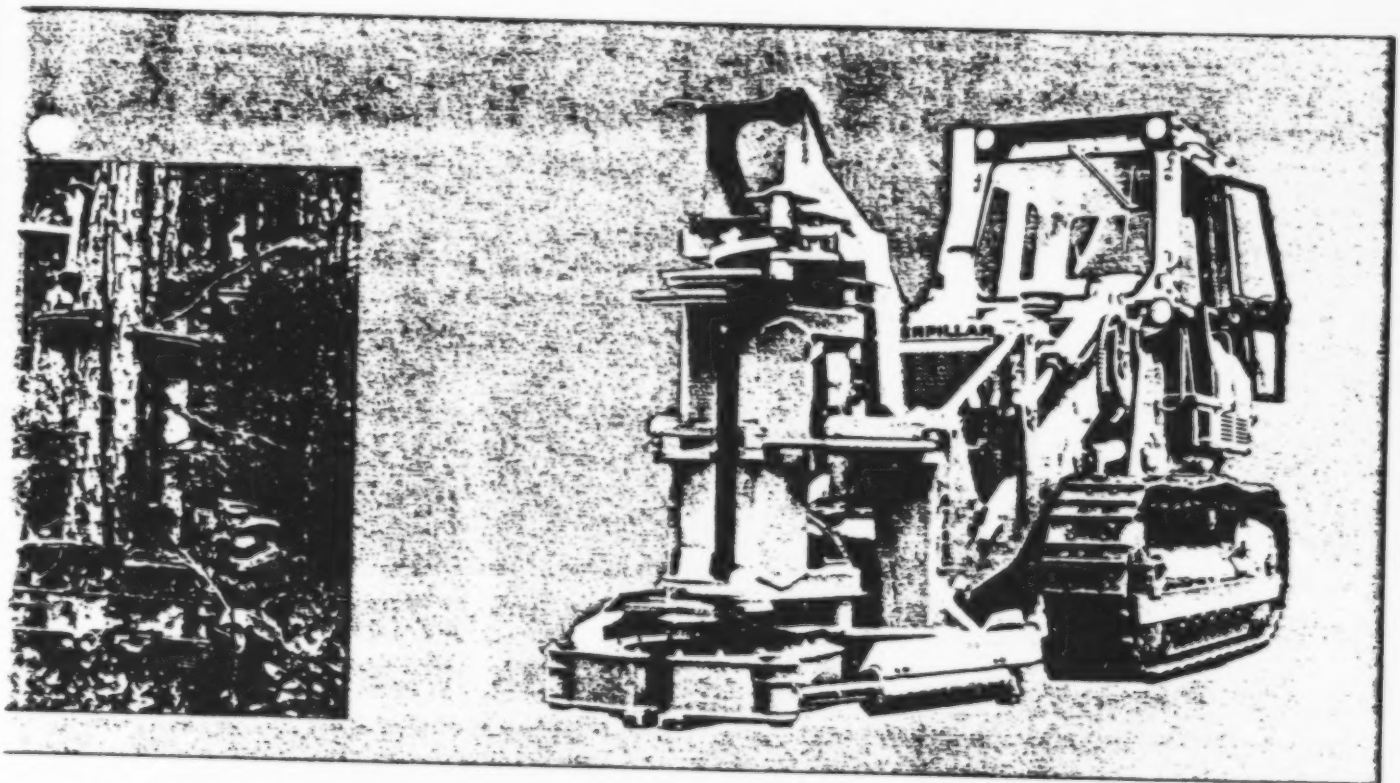
Form 728
Replaces 716 and 717



Fleco Feller-Bunchers are designed primarily to cut softwood trees; however, they can be used at reduced capacities to cut hardwood trees. Two models are available, one with a 20 inch (508 mm) cutting capacity and the other with a 15 inch (381 mm) cutting capacity. The accumulator, which collects trees in the Feller-Buncher is available for both models. These Feller-Bunchers are easy to operate, working smoothly through cutting and dropping cycles because clamps and blades are controlled by a single lever. By bunching trees for skidders the Feller-Bunchers contribute to a more productive log skidding operation.

An accumulator for gathering trees in the Feller-Buncher is available as optional equipment. **With the accumulator, small to medium sized trees can be collected and held after cutting by the Feller-Buncher.** Trees are cut and accumulated in a smooth and continuous motion providing a highly efficient shearing and bunching operation. **The optional stem accumulator allows the operator to build his skidder loads right on the machine, without having to travel to the pile with each and every stem. This feature can increase total logging production in small stems by over 50%.**

An alloy steel bumper is built into the frame assembly of the Feller-Buncher. The bumper

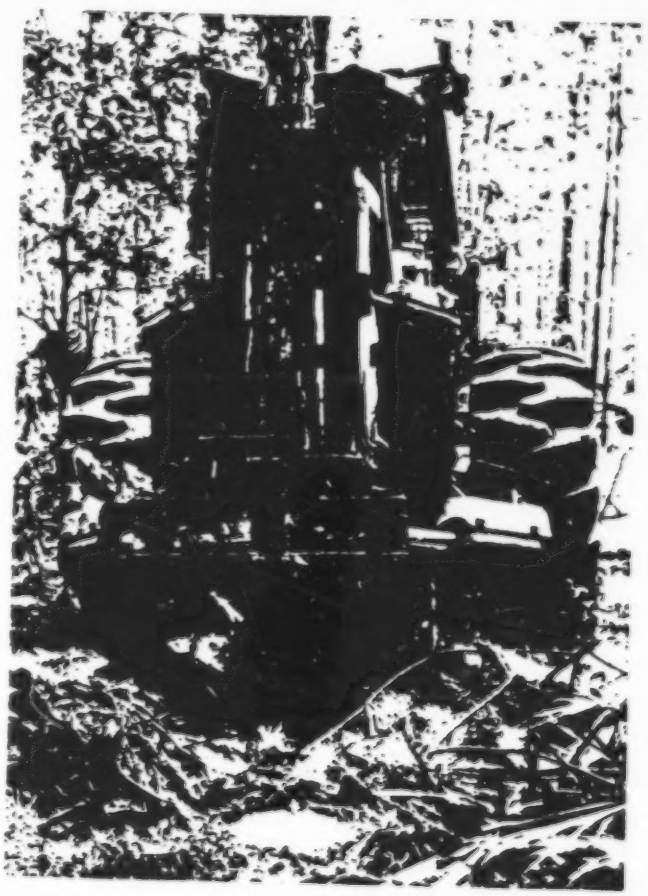


provides a quick, positive way of determining that the tree is correctly positioned for clamping and cutting. Correct positioning is done by crowding the bumper against the tree. The Feller-Buncher then clamps and cuts the tree when the operator activates the clamp/cut control.

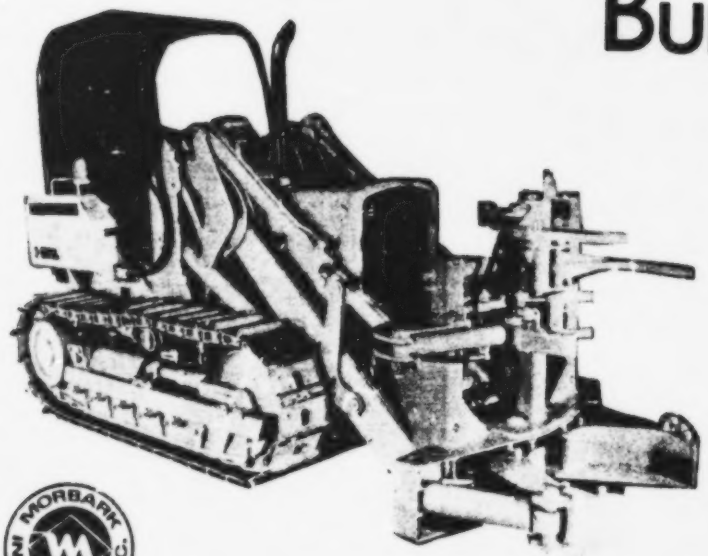
Four clamps hold the tree in position for cutting. The two cutting blades of the Feller-Buncher are alloy steel. They are held in the frame by bolts, however, each is seated firmly against two steel blocks. The blocks are welded to the frame assembly. In this design, the forces which are developed while cutting a tree are transmitted from the blades through the blocks to the frame assembly. A lug on the lower front of each blade prevents either blade from riding up over the other one.

All pivot points on the Feller-Buncher are lubricated through the pivot pins. The lubrication fittings are protected from damage by the pin retainers.

Trees cut with the Fleco Feller-Buncher show a markedly reduced stump height, which results in considerably more wood volume harvested per tree. Stump height provided by this twin blade unit range from 4 to 6 inches less than a guillotine type unit. This additional production is realized at no increased cost.



MORBARK 10" Feller Buncher Shear

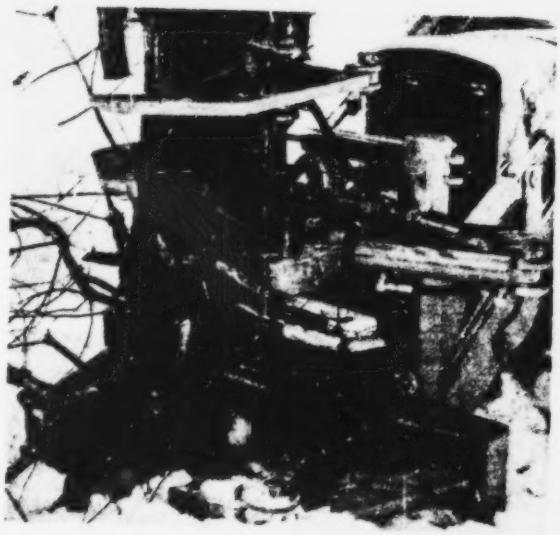


The same quality and craftsmanship that has made the Morbark 15" and 20" Feller-Buncher Shear the most popular head on the market has been incorporated into the 10" unit. Mounted on a maneuverable carrier, the 10" Shear will work well for thinning and will be used along with bigger carriers and shears to cut smaller diameter trees which may be difficult for bigger carriers to economically cut.

MORBARK'S STANDING OFFER

Morbark has a standing offer at its Winn, Michigan plant. Morbark will mount any Morbark Shear on any appropriate carrier provided by an equipment manufacturer, an equipment dealer or a producer. Morbark will work to help find out if its Feller-Buncher Shear will work on the kind of equipment that you manufacture, sell or own.

The woods vehicle should have the hydraulic capacity that we recommend and it must be reasonably fit for use as a feller-buncher. Even though the carrier which you feel would make a good feller buncher does not have our recommended hydraulic capacity, we ask that before discounting it as a possible carrier you check with our production people to make sure that our Shear cannot be made to work satisfactorily with your carrier. Although we would like the hydraulic capacity that is recommended on our spec sheet, there have been a number of occasions when a carrier with the smaller hydraulic system has successfully mated with our Shear.



Dealerships are available. If interested call or write.

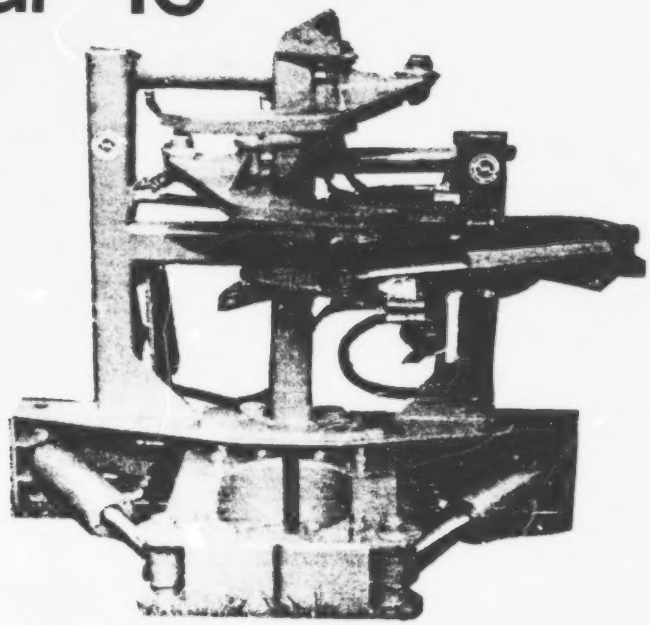
MORBARK INDUSTRIES, INC.

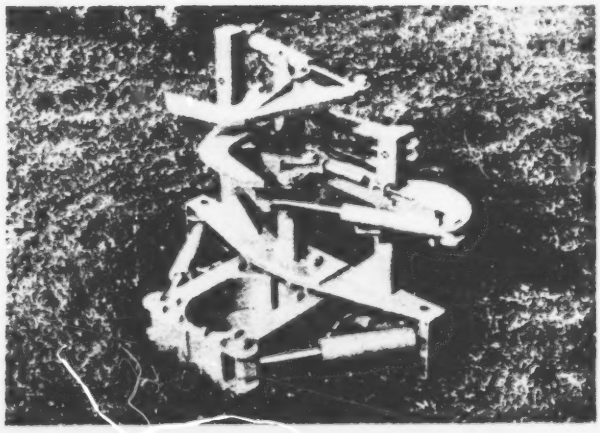
WINN, MICHIGAN 48896 • 517-866-2381 • TELEX 227 443 (MORBARK WINN)

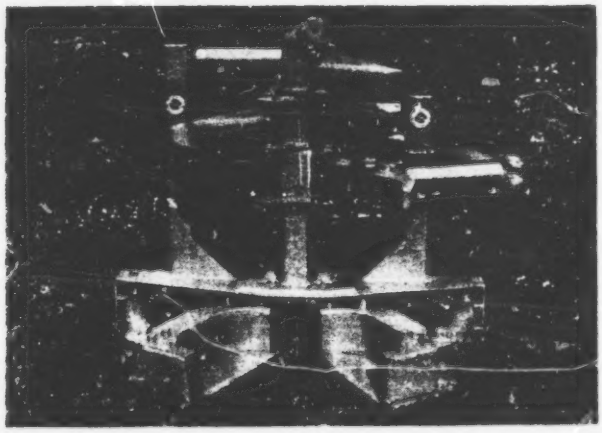
033079

142

Feller Buncher Shear–10"







GENERAL DIMENSIONS

Width . . . . . 34" w/o Mounting Brkt.
Length . . . . . 60"
Height . . . . . 54"
Weight . . . . . 1300 lbs.
Note: Different Mounts may Alter Weight.

HYDRAULIC SYSTEM REQUIRED FOR PROPER SPEED & FORCE.

24-30 GPM

2000 - 2400 PSI — Note: Lower PSI systems should consult Morbark Shear Engineer.

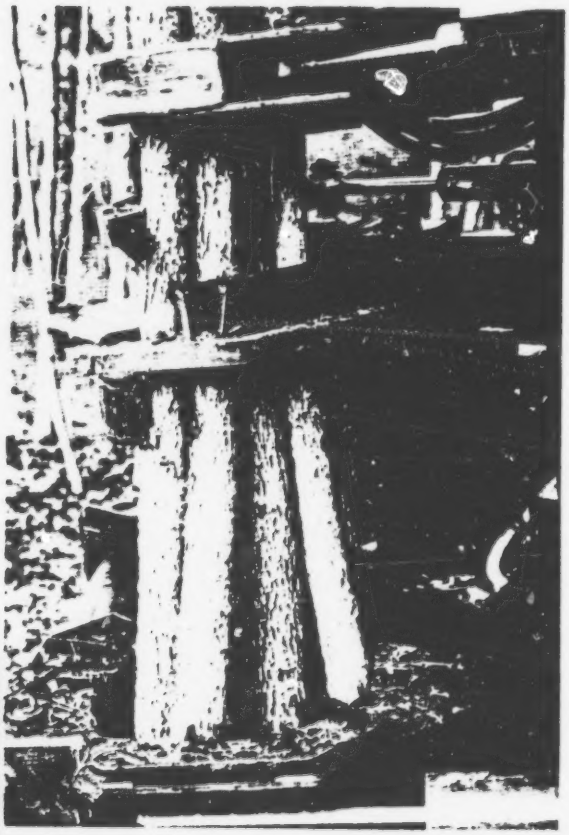
Two valves are needed to operate Shear, both being 4 way, 3 position, spring to center.

FEATURES

1. Shear designed to cut 8"–10" diameter hardwood.
2. Morbark's Feller Buncher Shear features the patented Gathering Device. This Gathering Device allows the Shear operator to accumulate 2 to 4 smaller trees before piling.

FBS10-1078

FELLER BUNCHER SHEARS



Equipped with **gathering arms** and **accumulating fingers,** the Morbark Feller Buncher Shear can easily and quickly gather and cut several small diameter trees before having to pile.

Morbark Shears Are Rugged Units Capable Of Shearing Large Diameter Trees:

Model 13"..... Up to 15" diameter softwood
Up to 13" diameter hardwood
Lightweight—ideal for thinnings

Model 17"..... Up to 17" diameter softwood
Up to 13" diameter hardwood
Double accumulator available for bunching small trees

Model 22"..... Up to 22" diameter softwood
Up to 17" diameter hardwood
Four cylinder design with sensing valves—provides speed for small diameter trees and power for big trees.

Morbark Shears are designed to **attach close to the carrier** increasing operator visability, reducing strain on the carrier and **increasing stability** for shearing and carrying tall trees.

FELLER BUNCHER SHEARS

13" SHEAR 17" SHEAR 22" SHEAR

MORBARK FELLER BUNCHER SHEARS
MODELS 13", 17" AND 22"
THE MOST DEPENDABLE ON THE MARKET

Manufacturing Experience—Since we began building Feller Buncher Shears in 1973, Morbark has built units that have been mounted on over 150 different carriers.

Because of their **heavy duty construction,** Morbark Shears have proven to be dependable in both hardwood and softwood.

A full line of Feller Buncher Shears . . . 13", 17" and 22". . . to meet your application and diameter requirements.

All knives are mounted at the bottom of the shear box allowing trees to be sheared at ground level.

Backed by **nationwide shear dealer network,** providing you with individual application assistance in sales, service and replacement parts. Contact Morbark, toll free at **1-800-621-3540** for the dealer nearest you.

FELLER BUNCHER SHEARS

22" FELLER BUNCHER SPECIFICATIONS

GENERAL
Width ..... 50" w/o mounting brackets
Length ..... 96"
Height ..... 85"
Weight ..... 5,300 lbs.
NOTE: Different mounts may alter weight

HYDRAULIC SYSTEM REQUIRED
- 40 to 60 GPM
- 2500 to 3000 PSI
- Two control valves are needed for function of shear, both being 4-way, 3 position spring to center valves.

17" FELLER BUNCHER SPECIFICATIONS

GENERAL
Width ..... 37" w/o mounting brackets
Length ..... 87"
Height ..... 57"
Weight ..... 2,300 lbs.
NOTE: Different mounts may alter weight

HYDRAULIC SYSTEM REQUIRED
- 40 to 60 GPM
- 2500 to 3000 PSI
- Two control valves are needed for function of shear, both being 4-way, 3 position spring to center valves.

13" FELLER BUNCHER SPECIFICATIONS

GENERAL
Width ..... 35"
Length ..... 68"
Height ..... 56"
Weight ..... 1,650 lbs.
NOTE: Different mounts may alter weight

HYDRAULIC SYSTEM REQUIRED
- 40 to 60 GPM
- 2500 to 3000 PSI
- Two control valves are needed for function of shear, both being 4-way, 3 position spring to center valves.

PRICES AND OPTIONS

MODEL 22" FELLER BUNCHER SHEAR

Additional Accumulating Finger	$ 880.00
Hydraulic Electric Solenoid Operated Divertor Valve for accumulating finger	$ 1,185.00
Air-Controlled Divertor Valve for accumulating finger	$ 675.00
Mounting Brackets Dozer Style Mount	$ 785.00
Mounting Brackets Loader Style Mount	$ 620.00

MODEL 17" FELLER BUNCHER SHEAR

Additional Accumulating Finger	$ 855.00
Hydraulic Electric Solenoid Operated Divertor Valve for accumulating finger	$ 1,185.00
Air-Controlled Divertor Valve for accumulating finger	$ 675.00
Mounting Brackets — Dozer Style Mount	$ 770.00
Mounting Brackets for most other carriers	$ 580.00
Tree Limiters	$ 360.00
6" Diameter Main Shear Cylinders in lieu of standard 5-1/2" diameter cylinders	$ 575.00

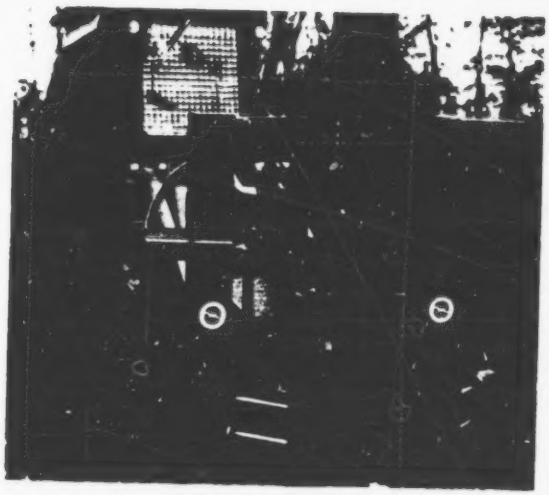
MODEL 13" FELLER BUNCHER SHEAR

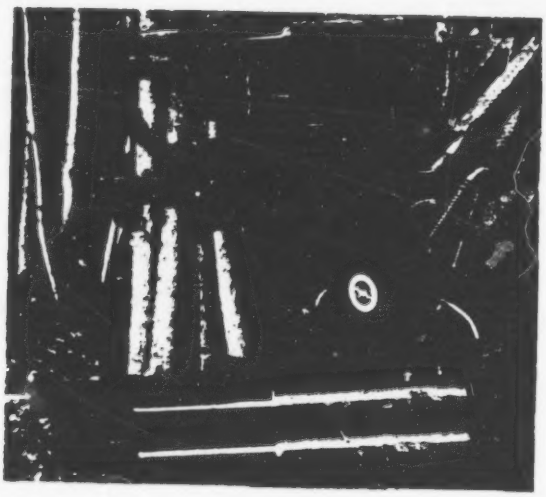
Mounting Brackets for MOST carriers	$ 535.00

FELLER BUNCHER SHEARS

All Morbark Feller Buncher Shears are rugged heavy duty pieces of equipment and Morbark Shears perform because:

1. They are designed for the toughest applications and are continually tested and improved upon at Morbark's proving grounds in Winn, Michigan.
2. All Morbark Feller Buncher Shears are built in jigs and are machined on the most up to date modern machining equipment.
3. All wear areas of the Feller Buncher are built with hardened steel pins and bushings.
4. The hydraulic lines consist primarily of hydraulic tubing and most lines are built into the frame of the shear. Flexible hose is used to attach to the carrier and all exterior lines are guarded and protected.





SHEAR BLADES ARE ADUSTABLE AND EASILY RESHARPENED

The Famous Morbark Single And Double Arm Accumulators Allow For The Cutting And Accumulating Of Several Smaller Diameter Trees Before Piling

One accumulating arm is standard and a second is optional and recommended for applications where the shear will be working primarily in small diameter trees. An accumulating cradle holds the trees upright.

Morbark's Feller Buncher Shear features the patented gathering device. This gathering device allows the shear operator to accumulate several smaller trees before piling.

Morbark's pressure-sensing valve (available on the Model 22) allows for a unique shearing design when shearing small or soft material. Only two cylinders are used for speed, for larger trees or hardwood, all four cylinders are in use for cutting force.

All shears are designed for hardwood or softwood. All points of wear are hardened steel bushings and chrome plated hardened steel bushings and chrome plated hardened pins.

All bushings and pins are replaceable and line bored for ease of fit.

Pins are held in place with Grade 8 bolts and self-locking nuts.

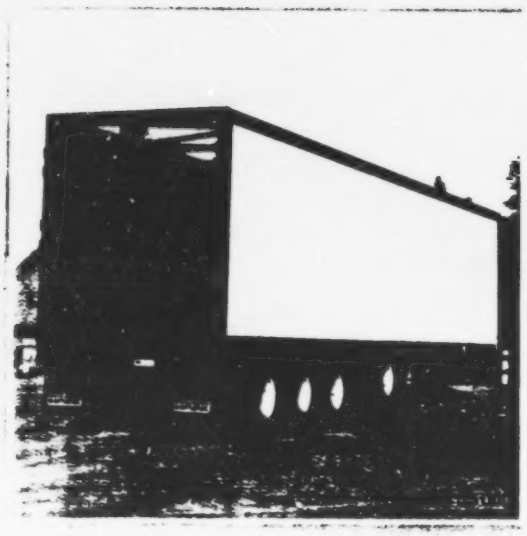
Cylinders are of rugged welded construction and hardened rods.

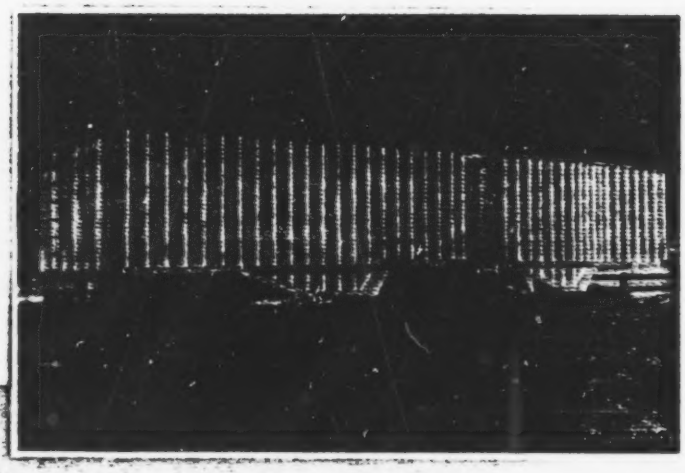
Spring guarded hose to increase hose life.

Special alloy heat-treated knives can be resharpened many times.

Appendix E

Specifications of Typical Truck Tractor and Semi-Trailer Chip Van





manac inc

model 34 000

MONTRÉAL
270, Chemin du Tremblay
Boucherville, Québec, J4B 5X9
Inwats: 1-800-361-7900
Tel.: (514) 527-8031 — Telex: 05-25819

QUÉBEC
660, Graham Bell
Ste-Foy, Québec, G1N 4C1
Tel.: (418) 658-6031

ST-GEORGES
2275, 107th street , C.P. 490
St-Georges, Beauce, Québec G5Y 5C8
Tel.: (418) 228-2018 — Telex: 05-833531

TORONTO
80, Costa Road, Maple, Ontario, L0J 1E9
Tel.: (416) 669-9719 — Telex: [illegible]

EDMONTON
17307, 107th Avenue
Edmonton, Alberta, T5S 1E8
Tel.: (403) 483-6114 — Telex: [illegible]

CHIP TRAILER
model 34000

omanac inc

MODEL
RD-600S
SERIES

STANDARD SPECIFICATIONS

(Based on Model RD685S)

ENGINE

Mack EM6-237
- Horsepower, 235 HP [175 kW] at 2100 Gov. RPM
- Max. Torque, 906 lb/ft. [1 228 N•m] at 1200 RPM
- Lube Oil System, Full Flow ESI
  - Extended Service Interval 16,000 Miles [25 749 km]
- Silicone Hoses and Tubing on Engine
- Air Compressor, 12.0 cfm [5.7 l/s] min. rtg

Starting System
- ***Starter,*** 12-Volt
- Batteries, (4) Mack 6-Volt, 1360 Total CCA
- ***Alternator,*** 12V 90A, Leece Neville

Air Intake System
- Air Cleaner, 13" [330 mm] Single Element
  - Dry Type, External Cowl Mtd.
- Air Cleaner Intake Cap, Painted
- Air Restriction Monitor, Grad. Lock Up Type
  - (Air Cleaner Mounted)
- ***Exhaust,*** Underframe

Cooling System - Shutterless Type
- Radiator, 1000 sq. in. [6 452 cm²] Frontal Area
- Anti-Freeze to -10°F [-23°C]
- Fan Drive, Viscous
- Hoses, Heater & Radiator, SAE Standard
- Coolant Conditioner, Spin-on

CLUTCH

- CL697, Spicer 14" [356 mm] Organic,
- Dampened Disc, 2-plate, Coaxial Spring

TRANSMISSION

- TRL1078 Mack 5-speed
- Ratios: 8.59 Low - 1.00 High
- P.T.O. Side Gears (RH & LH)

Driveline: Rockwell 17N HD Main & Interaxle w/Coated Splines

CAB/HOOD

CAB CA49
- Conventional

Interior Features

Basic:
- Ash Tray
- Cigar Lighter
- Coat Hook
- Dispatch Box
- ***Heater with Integral Defroster***
- Dome Light w/Self-Contained Switch
- Adjustable Steering Column
- Seats
  - Driver's, Mack, Non-Suspension
  - Rider's, Mack, Non-Suspension
- Seat Belts - Driver's and Rider's
- Sun Visor - Left Side
- Floor Mats, Rubber w/Closed Cell Polyethylene Backing

CAB/HOOD (Continued)

Operational
- T.M.C. Recommended Instrument Panel
- Air Pressure Gauge
- Voltmeter
- Fuel Level Gauge
- Engine Oil Pressure Gauge
- Engine Coolant Temperature Gauge
- Low Air Pressure Indicator
  - (Light and Buzzer)
- Speedometer/Odometer
- Tachometer w/Totalizer
- High Beam Indicator
- Parking Brake On Indicator
- Key Type Starting
- Hand Throttle Control
- Engine Stop Control
- Courtesy Light Switch (Head & Clearance)
- Directional Signal Switch, Manual Cancelling

Exterior Features

Basic:
- Welded Steel Shell, Galvanized
- Mack Rust Preventative Procedures
- Vents (Screened)
  - Cowl - L.H. One Way Type
    - Upper, Fresh Air Inlet for Heater
  - Roof - Two Way Type
- Cab Step, R.H. - Frame Mtd.
- Safety Glass Windows
- Tinted Windshield
- Windshield Wipers - Two, Fixed Arm and Blade Type
- Wiper Motor (Air Operated), (1), Variable Speed
- Windshield Washers, Electric, Wiper Mtd. with 5 Qt. [4.7 l] Reservoir
- ***Mirrors,*** West Coast (Black Enamel Heads) R.H. & L.H.
- Headlights, (2) Conventional Sealed Beam Type (7" [178 mm] Round)
- Identification and Clearance Lamps (5)
- Side Markers - Lamps and Reflectors
- Front Turn Signals
- 4-Way Flashers
- ***Horn*** Electric (Single Tone)
- Doors - Galvanized Steel with:
  - Roll-Up and Vent Windows (Non-Tinted)
- Grab Handles (Stainless Steel), R.H. & L.H. Behind Door
- Rear Cab Glass (Non-Tinted)

Cab Mounting
- Trunnion Front, Fixed Rear

Hood and Fenders
- One Piece Fiberglass with Wheel Splash Aprons
- Tilts Forward 75°
- Fixed Vane Grille (Chassis Mtd.)

RD-600S

FRAME
WB - Wheelbase - 163" [4 140 mm]
LP - Load Platform - 133" [3 378 mm]
CA - Cab to Axle - 84" [2 184 mm]
AF - C/L Axles to End of Frame - 49" [1 245 mm]
Frame Rails - Steel
Cross Section, 10-5/8" x 3-1/4" x 5/16" [270 x 83 x 8 mm]
Section Modulus - 14.27 in^3 [233.8 cm^3]
RBM (per rail) - 1,570,000 lbs. in. [177 000 N•m]

Bumper: Steel, Swept Back Channel, 92.6" x 10" [2 352 x 254 mm]
Extended Mounting
B.B.C. 112" [2 845 mm]

Towing, Pins

FUEL TANK
Steel, 24" [610 mm] Dia. Step Type
Capacity/Location, 55 Gal., [208.2 L] L.H.

FRONT AXLE
FAW 536C, Mack
10,500 Lb. [4 800 kg] Capacity

Brakes, "S" Cam (16.5" x 5" x 0.75") [419 x 127 x 19 mm]

Suspension, Mack Taperleaf Spring with 10,500 Lb. [4 800 kg] Ground Load Rating

Shock Absorbers

Oil Seals

Steering, Ross 503 Gear, Manual Type
12,000 Lb. [5 400 kg] Capacity, Ratio 32.5:1
Wheel Equipment Cast Spoke
Rim 7.5" [191 mm]

REAR AXLE
SS34C, 34,000 Lb. [15 400 kg] Capacity Mack Axle
Carriers - Malleable - CRDPC92/CRD93

Ratios Available: 4.17, 4.42, 4.64, 5.02, 5.32, 5.55, 5.73, 6.06, 6.34, 6.56, 7.00, 7.13, 7.49, 8.24, 9.15

Suspension - Mack, 34,000 Lb. [15 400 kg] Capacity
Camelback Spring, Anti-Sway Type
2 Shock Abs. of Fwd Axle
50" [1 270 mm] Axle Wheelbase
Oil Seals

REAR AXLE (Continued)
Brakes - "S" Cam (16.5" x 7" x 0.75") [419 x 178 x 19 mm]
Aux. Spring Brake Chambers
Double diaphragm type, mechanical spring release
4 Units, 2 mtd. each axle
Wheel Equipment Cast Spoke
Rim 7.5" [191 mm]

TIRES
Front (Singles), Size 10.00-20, 12 ***Ply***
Tread Highway Type
Vendor Factory Option
Rear (Duals), Size 10.00-20, 12 ***Ply***
Tread Highway Type
Vendor Factory Option

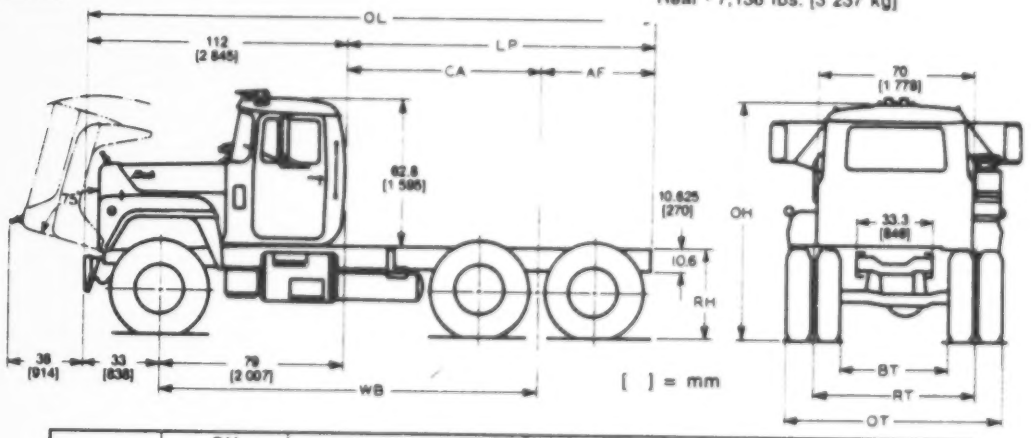
AIR/BRAKE
Dual Air Brake System
Air Reservoirs -
Two, one supply tank mounted inside LH frame rail and one dual tank compartment primary/secondary tank mounted under LH frame rail
Capacity - 4,536 $in.^3$ [74.3 l]

ELECTRICAL
Chassis Electrical
Negative Ground
12-Volt Electrical Circuits and Bulbs
Circuit Breakers
Rear Lighting, (2) Combination stop, tail, directional & back-up lights

PAINT
Cab, Hood and Fenders
Color: Mack White
High Gloss Acrylic Enamel

Chassis Running Gear
Color: Mack Black
Low Luster Alkyd Enamel

ESTIMATED CHASSIS WEIGHT
Front - 6,629 lbs. [3 007 kg]
Rear - 7,136 lbs. [3 237 kg]



TIRE SIZE	OH (APPROX.) Inches [mm]	RH Inches [mm]		FRONT TREAD Inches [mm]	OT Inches [mm]	RT Inches [mm]
		UNLOADED	LOADED		SPOKE WHEELS	
10.00-20	102.8 [2 611]	40.0 [1 016]	38.3 [973]	81.4 [2 068]	94.9 [2 411]	71.0 [1 803]
10.00-22	103.8 [2 637]	41.0 [1 041]	39.2 [996]	81.4 [2 068]	94.9 [2 411]	71.0 [1 803]
11.00-20	103.4 [2 626]	40.6 [1 031]	38.8 [986]	80.9 [2 055]	96.1 [2 441]	71.2 [1 809]
11.00-22	104.4 [2 652]	41.6 [1 057]	39.7 [1 008]	80.8 [2 052]	96.1 [2 441]	71.2 [1 809]

Chassis dimensions are for standard chassis unless otherwise denoted. Frame heights are subject to variations: 1" [25 mm] unloaded, 0.5" [13 mm] loaded. Illustrations are not necessarily a representation of standard specifications.

This Chassis conforms to all federal requirements applicable at time of manufacture
Specifications Subject to Change Without Notice

OPC 8M 0484

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